390

TECHNICAL LIBRARY 1941
REFERENCE COPY
AD A003 280

TECHNICAL REPORT NO. 11850

APPLICATION TECHNIQUES AND METHODS FOR APPLYING FUSED CARBIDES ON NON-LUBRICATED WEAR SURFACES FOR HIGH VOLUME PRODUCTION

U. S. ARMY TANK-AUTOMOTIVE COMMAND
CONTRACT NO. DAAE07-71-C-0148
MM&T PROJECT NO. 4704287

June 1974

Reproduced From
Best Available Copy

by P.H.Brotzman, E.H.Drewes, N. Wulff
Firestone Tire and Rubber Company
Metallurgical Laboratory

AN 276 89

TACOM

Approved for public release; distribution unlimited.

VEHICULAR COMPONENTS & MATERIALS LABORATORY
U.S. ARMY TANK AUTOMOTIVE COMMAND Warren, Michigan

CODE SHEET INCLOSED

20020723163

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of commercial products in this report does not constitute an official indorsement or approval of such products.

Destroy this report when it is no longer needed. Do not return it to the originator.

Technical Report No. 11850

APPLICATION TECHNIQUES
AND
METHODS FOR APPLYING FUSED
CARBIDES ON NON-LUBRICATED
WEAR SURFACES FOR HIGH VOLUME PRODUCTION

Final Report

by

P. H. Brotzman
E. H. Drewes
N. Wulff

CODE SHEET INCLOSED

Contract No. DAAE07-71-C-0148

U.S. Army Tank-Automotive Command
Warren, Michigan 48090

AMCMS CODE

THIS CODE SHEET WILL BE REMOVED FROM THE REPORT WHEN LOANED OR DISTRIBUTED OUTSIDE THE DEPARTMENT OF DEFENSE.

CODE SHEET

Report No. 11850

CODE	PRODUCT	MANUFACTURER
N	Fusecote	Napco Industries
ASB-1	Metco 15E	Metco
ASB-2	Metco 34F	Metco
I6A	Ingersoll #6A	Ingersoll Products Division of Borg Warner
I5	Ingersoll #5	Ingersoll Products Division of Borg Warner
I5W	Ingersoll #5W	Ingersoll Products Division of Borg Warner
E10009	Eutectic 10009	Eutectic Corporation
W63	Colmonoy #63	Wall Colmonoy
W705	Colmonoy #705 (WC125)	Wall Colmonoy
S65TG	Stoody 65TG	Stoody Company
S65WTG	Stoody 65WTG	Stoody Company
C101	Composite Science Formaflex WC/CrNi (101)	Composite Science (Mallory Composites, Inc.)
C601	Composite Science Formaflex Cr_3C_2/CrNi (601)	Composite Science (Mallory Composites, Inc.)
C603	Composite Science Formaflex CrNiB (603)	Composite Science (Mallory Composites, Inc.)

TABLE OF CONTENTS

ABSTRACT

Application techniques and methods for applying various commercially available types of fused carbides were studied. The non-lubricated wear surfaces of forged steel track shoes were used in this study.

900 track shoes were produced in total using four hard surface combinations. The track shoes were tested at Aberdeen Proving Ground and Yuma Proving Ground.

Examination of the four types of hard surfaced shoes after field testing revealed little difference in the rate of wear between the different types. All hard coatings were penetrated at approximately 1,000 miles. The cost of mass producing an induction hardened wear surface on a T130 track shoe is less than that of a mass produced fused carbide hard coat on the same shoe.

During the field testing, very few cracked shoes were observed in either the control or test group. However, Yuma Proving Ground indicated that standard induction hardened T130 track shoes showed 45% less grouser wear than hard surfaced T130 shoes. The standard T130 induction hardened shoe also appeared to have less wear at Aberdeen Proving Ground with the exception of the longer lasting, inboard corner of the front grouser. This inboard corner was on shoes with the tape method of application produced by Code C601.

During the investigation production processes using furnace fusion were selected. A comparison between metal spray, slurry, and decal methods of application was made. The equipment and

techniques of Company Code I6A were readily adaptable for reproducible good quality fused carbide coatings on non-lubricated wear surfaces of track shoes. Company Code I6A has developed equipment, techniques, and personnel for hard surfacing agricultural implements on a production basis, making their slurry process reliable and economical when compared to the less sophisticated metal spray and decal methods of application.

FOREWORD

The investigative work described in this report was performed by the Firestone Tire & Rubber Company and was a joint effort between the Firestone Metallurgical Laboratory, 1200 Firestone Parkway, Akron, Ohio and Firestone Industrial Products, Noblesville, Indiana. All work was performed under contract DAAE07-71-C-0148 and modification P00001 to the contract.

This project has been accomplished as part of the U. S. Army Manufacturing Methods and Technology Program, which has as its objective the timely establishment of manufacturing processes, techniques, or equipment to insure the efficient production of current and future defense programs.

The work under Phase I was performed at the Firestone Metallurgical Lab under the supervision of Mr. P. H. Brotzman, Chief Metallurgist. The pilot lot production run under Phase II included the hard surfacing of the experimental track shoes at the subcontractor's plant locations with the rubberizing and assembly of the track shoes at Firestone Industrial Products. Field testing under Phase III was performed at Aberdeen Proving Ground and Yuma Proving Ground with the analysis of production capabilities, the development of quality assurance criteria, and the cost estimation of the various techniques being performed by Firestone Industrial Products under the direction of N. Wulff, Manager, Government Sales.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Many design concepts utilized in tank-automotive components are subjected to non-lubricated wear. Normal practice for wear surfaces is to use steels with sufficient hardenability and then flame or induction harden these surfaces to a high hardness. Recent development indicated that a coating of metallic compositions impregnated with carbides, such as tungsten, can be used with satisfactory results. These coatings can be bonded to the wear surface, thus eliminating the need for wear through surface hardening treatment. Matrix materials which hold the carbides firmly can be bonded either metallurgically or mechanically to the wear surface. The composition of matrix material can have sufficient hardness as well as the ability to firmly hold the hardened particles (carbides).

Earlier work at TACOM demonstrated that a matrix of nickel, cobalt and boron with crushed tungsten carbide particles improved wear characteristics over the conventional flame or induction hardening method. This matrix material was capable of making a metallurgical bond with the base alloy steel, utilizing short time temperatures of 2,000^{o}F. Since the success of utilizing the hard face alloys was thought to depend on a minimum of 0.025 of an inch thickness, the total thickness of the coating had to be built up in layers. The powders which are fused to form the total coating thickness must be held firmly in the desired locations prior to fusing.

SCOPE OF WORK AND OBJECTIVE

For many years it has been the standard practice to induction or flame harden the wear areas of T130 tank track shoes. Since the T130 track shoe is a high volume production item, it was selected for the application of fused carbide coatings in order to determine the economics and feasibility of utilizing fused carbide coatings. The wear surfaces of the T130 track shoe are:

1. The surfaces of the track shoe grousers which contact the ground.
2. The areas of the sprocket window where the sprocket tooth contacts the track shoe.
3. The sides of the center guide which contact the wear rings or shields of the road wheels.

The objective of this investigation is to establish the feasibility as well as the techniques and methods for applying fused carbides on non-lubricated wear surfaces for high volume production tank-automotive items such as track shoes.

After the systematic metallurgical survey defined in Part I, a more definite objective of a comparison of the metal spray, slurry, and decal methods of application was stated. A comparison under field service of the following materials was also planned:

Tungsten Carbide vs. Chromium Carbide
An 80 mesh Tungsten Carbide vs. 200 mesh Tungsten Carbide
An Iron Base Matrix vs. a Chrome, Nickel, Boron Matrix

This study consisted of three parts as follows:

PART I:

A systematic metallurgical survey of potentially desirable hard surfacing materials and application methods followed by a laboratory evaluation of the various candidate materials. The basis of this study was to assess the feasibility of each method including the relative wear resistance of the candidate materials.

PART II:

A pilot lot production run of approximately 900 shoes hard surfaced with four different materials selected on the basis of Part I tests.

PART III:

Field testing and evaluation of the four materials used in Part II plus the analysis of production capabilities, development of quality assurance criteria, and cost estimation of the various techniques.

PART I - SURVEY OF THE HARD COATING FIELD

Hard surfacing materials and methods may be outlined as follows:

Materials

1. Composite Tungsten Carbide
2. High Chromium Irons
3. Austenitic Irons
4. Cobalt Base Surfacing Metals
5. Nickel Base Alloys
6. Martensitic Steels plus added carbides

Application Methods

1. Manual Oxyacetylene-bare rods
2. Manual Oxyacetylene-powdered filler metal
3. Semi-automatic Oxyacetylene-powdered filler metal
4. Manual Arc Surfacing-coated rods
5. Submerged Arc Surfacing
6. Gas Tungsten Arc
7. Gas Metal Arc
8. Atonic Hydrogen
9. Thermal Spraying (Metallizing) and Fusing
10. Plasma Arc-powder surfacing
11. Furnace Brazing

In view of the large production requirements, the manual oxyacetylene and manual arc methods were immediately eliminated from serious consideration. The automatic and semi-automatic methods were considered, but due to the geometry of the areas to be covered, it was concluded that the tooling and fixture development costs would be excessive for this study. These methods were therefore abandoned for this project.

The evaluation of the cobalt base alloys was not pursued due to their comparative high cost. The austenitic irons were also discarded due to their anticipated lower abrasion resistance.

The Part I study was conducted on the following materials and processes:

Sample #1

Prepared by: Code FML
Steel 4140, heat treated to Rockwell "C" 52

Sample #2

Prepared by: Code FML
Steel 4140, heat treated to Rockwell "C" 54

Sample #3

Prepared by: Code N
Material: 60/80 mesh WC in a Cr-Ni-B Matrix (AWS BN1-1; AMS 4775)
Process: No details revealed

Sample #4

Prepared by: Code ASB-1
Material: Cr-Ni-B self fluxing alloy
Process: Plasma spray and furnace fusing in a reducing atmosphere

Sample #5

Prepared by: Code ASB-2
Material: Cr-Ni-B self fluxing alloy plus 50% 270 mesh or finer WC
Process: Plasma spray and furnace fusing in a reducing atmosphere

Sample #6

Prepared by: Code I6A
Material: Iron base matrix plus FeC_3, CrC, B
Process: Coating applied as a paste and fused in conveyor furnace

Sample #7

Prepared by: Code I5
Material: Nickel base matrix with chrome, Boron and Iron
Process: Same as Sample #6

Sample #8

Prepared by: Code I5W
Material: Nickel base matrix with Chrome, Boron and Iron and Tungsten Carbide particles
Process: Same as Sample #6

Sample #9

Prepared by: Code W6
Material: A Nickel, Chrome, Boron and Silicon Alloy with Chrome Boride Crystals
Process: Spray-Welder Torch

Sample #10

Prepared by: Code E10009 at Code FML
Material: A 140 mesh atomized Nickel Boride Powder
Process: Fuse Welder Torch

Sample #11

Prepared by: Code W63
Material: A Nickel, Chrome, Boron and Silicon Alloy Matrix
Process: Spray-Welder Torch

Sample #12

Prepared by: Code W705
Material: 200 mesh Tungsten Carbide particles in a Chrome, Nickel, and Boron Matrix
Process: Fuse Welder

Sample #13

Prepared by: Code S65TG
Material: A Nickel, Chrome, Boron and Silicon Alloy Matrix
Process: Fuse Welder

Sample #14

Prepared by: Code S65WTG
Material: 200 mesh Tungsten Carbide particles in a Nickel, Chrome, Boron and Silicon Alloy Matrix
Process: Fuse Welder

Sample #15

Prepared by: Code C101
Material: WC/CrNi Cloth-Tape
Process: Tape/Hydrogen furnace atmosphere

Sample #16

Prepared by: Code C601
Material: Cr_3C_2/CrNi Cloth-Tape
Process: Tape/Hydrogen furnace atmosphere

Sample #17

Prepared by: Code C603
Material: CrNiB Cloth-Tape
Process: Tape/Hydrogen furnace atmosphere

All samples were first quenched and tempered to a Rockwell hardness of 25-30 Rockwell C, and then cut into 1 inch squares and weighed. They were compared for weight loss by running the sample without lubrication against an 80 mesh abrasive belt with a constant load. The tests were run for 15 minutes each and the samples reweighed. The weight loss was noted. Three tests of each material were made and the results were averaged. The abrasive belt was changed between each test.

The results are tabulated in graphic form in Table 1. While differences in weight loss between the various materials were observed, it should be noted that all of the hard facing alloys performed much better on this test when compared to the two control specimens which were hardened to Rockwell C50-52 to duplicate the hardness of the induction hardened areas on the T130 track shoe.

PART II - PILOT LOT PRODUCTION

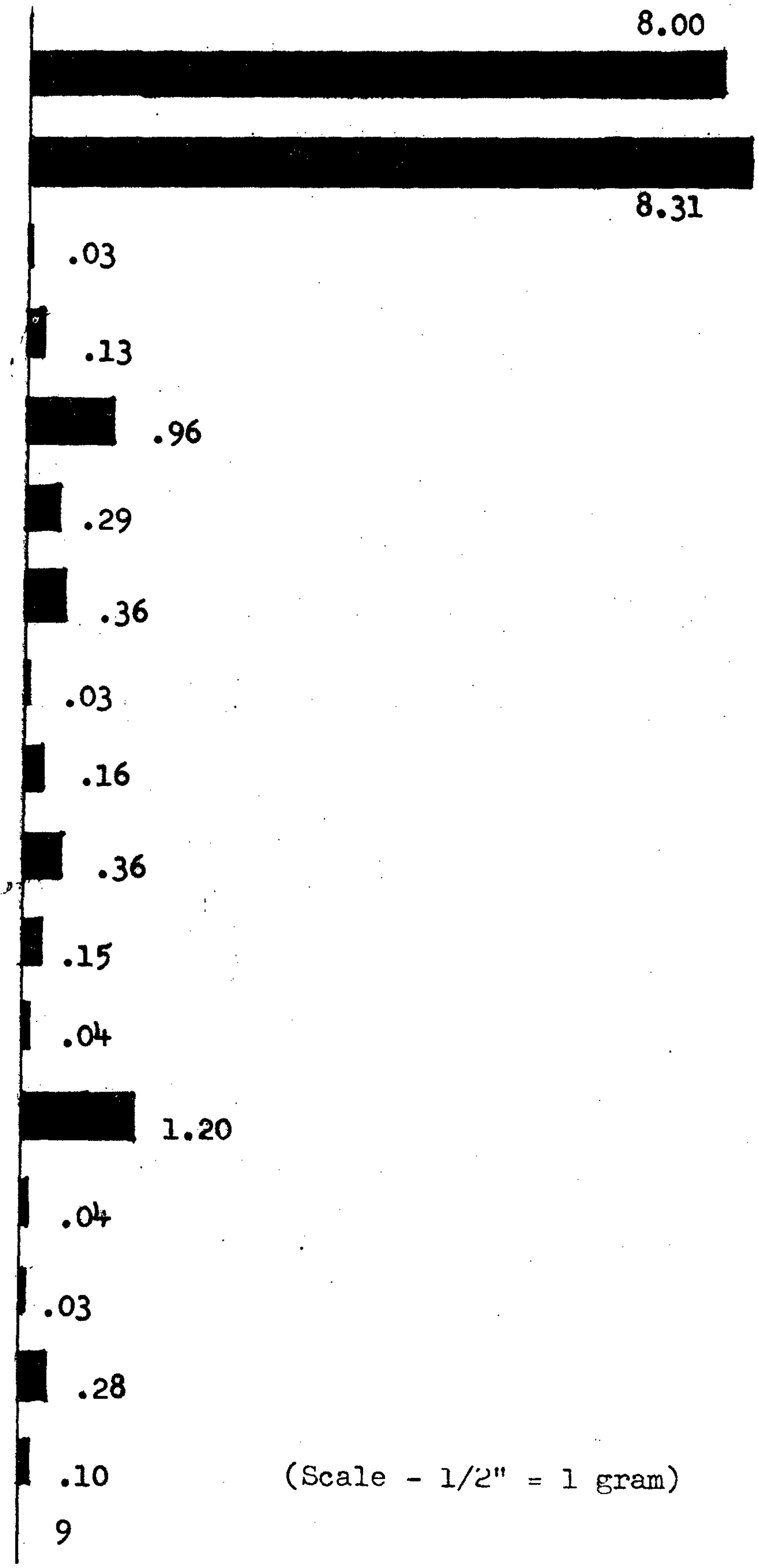
After a review of the results it was decided to have 249 shoes hard surfaced by each of four vendors using the techniques summarized below:

Vendor	Method of Application	Method of Fusing	Furnace Atmosphere
Code C601	"Tape" cemented to specific areas with volatile adhesive	Batch Type Furnace	Dry Hydrogen
Code I6A	"Slurry" dispensed on the specific areas	Continuous Belt Furnace	Endothermic
Code N	UNKNOWN	UNKNOWN	UNKNOWN
Code 705	WC-125 "Tape" cemented to specific areas with volatile adhesive	Batch Type Furnace	Dry Hydrogen

Table 1

ABRASION TESTS
(weight loss in grams)

MATERIAL	
1. 4140 - 52 RC	8.00
2. 4140 - 54 RC	8.31
3. Code N	.03
4. Code ASB-1	.13
5. Code ASB-2	.96
6. Code I6A	.29
7. Code I5	.36
8. Code I5W	.03
9. Code W6	.16
10. Code E10009	.36
11. Code W 63	.15
12. Code W 705	.04
13. Code S65TG	1.20
14. Code S65WTG	.04
15. Code C101	.03
16. Code C601	.28
17. Code C603	.10



(Scale - 1/2" = 1 gram)

CODE 601 - TAPE (CLOTH) METHOD OF APPLICATION

The material used in this hard surfacing technique is a powdered metal cloth similar to a thin sheet of pie dough. The sheet contains powdered metals and carbides and can be rolled out to the desired thickness. The tape or cloth is then cut with sheers or knives to conform to the surface to be coated. A cement of proprietary composition is used to adhere the hard surfacing cloth to the article to be hard surfaced. Material is glued in place similar to the manner in which mucilage is applied to paper. After the powdered metal and carbide is laid on the article a second coat of adhesive and a second layer of nickel-chrome-boron brazing alloy is applied.

The brazing alloy is the matrix and serves as the binder for the carbides. The two layer techniques permits the brazing alloy to flow around the carbides during fusion rather than combine all the ingredients in a single film. However, this double method of application can probably be eliminated to facilitate mass production.

The heat treating cycle is used to fuse the tape (cloth) to the article and lasts approximately six hours and is done in the progressive steps as follows:

1. Bake at 200 - 300 degrees F.
2. Heat to 800 - 1000 degrees F. and hold to destroy the binder.
3. Raise temperature to 1700 degrees F. and hold to equalize temperature.
4. Raise to proper fusion temperature for the specific alloy.
5. Cool in furnace.

The vacuum furnace used in the production of the pilot lot of shoes was approximately 36" in diameter and 48" deep with a weight carrying capacity of one ton. However, the largest load processed at the time of our inspection was 1200 pounds. Approximately 50 to 60 shoes could be processed in one batch.

During the preparation of samples, this vendor experienced problems with adhesion or "surface wetting" with the vacuum furnace fusing of the selected sample material. Spotty adhesion was visually apparent in all locations but the addition of nickel to the chromium carbide eliminated the problem and produced excellent results.

At the time of our investigation no high volume mass production process existed for this particular method of application although such a process seemed entirely feasible. An alternate fusion method using resistance heating had been tried on small parts by this firm and the hard coatings had been fused to the base metal in a matter of seconds. This method of resistance heating is very similar to the process now used to induction harden wear surfaces on T130 track shoes. Such an approach has definite potential for high volume production but would require a considerable amount of development and tooling expense that was beyond the scope of this investigation.

CODE I6A - SLURRY METHOD OF APPLICATION

Company Code I6A has had considerable experience with fused coatings and has developed equipment, techniques, and personnel for the hard coating of agricultural implements on a production basis.

The equipment and techniques are readily adaptable for high quality and high consistency fused coatings on T130 track shoes.

The coating, in the form of a slurry, was applied to the sample lot by dipping the horn and grousers of the track shoe. The coating was applied to the sprocket window areas with a recirculating stream of the slurry. The shoes were then cycled through a drying oven which solidified the coating. After the drying oven the coating could be easily contoured or removed by sanding or filing. Minor repairs could be made by applying a second slurry with a small brush.

Prior to entering the continuous belt furnace, the track shoes were supported with the grousers in the down position. The track shoes then passed into the high temperature furnace for fusing and cooling with a controlled gas protective atmosphere. The furnace temperature can be adjusted to control running or dripping of the coating. Once the optimum temperature has been determined, it is probable that very close control can be maintained resulting in completely fused uniform coatings on all areas of the track shoe.

CODE 705 - TAPE METHOD OF APPLICATION

Company Code 705 experienced problems with their tape or decal type of coating because the coating separated from the base metal before reaching fusing temperature in the furnace. A batch-type dry hydrogen furnace was used and after additional development work, the separation problem was solved.

The tape or decal is also applied with a volatile adhesive in this process. Slight adjustments in the formulation of the material and the temperature of the furnace produced the desired results.

CODE N - UNKNOWN METHOD OF APPLICATION

Company Code N would not release information on the method of application or fusing.

FUSION TEMPERATURES

All fusion temperatures were approximately 2000 degrees F. adjusted slightly for the specific matrix alloy being used. After completion of the hard coating, all four lots were shipped to American Metal Treating, Crystal Lake, Illinois, for heat treating and machining. No problems were encountered during these operations.

After heat treating, a sample shoe from each lot was sectioned in the same manner as induction hardened shoes are normally sectioned. The thickness of the hard surfacing material was measured. Photographs of these section samples showing the hard coating thickness are shown as Figures 1 through 8.

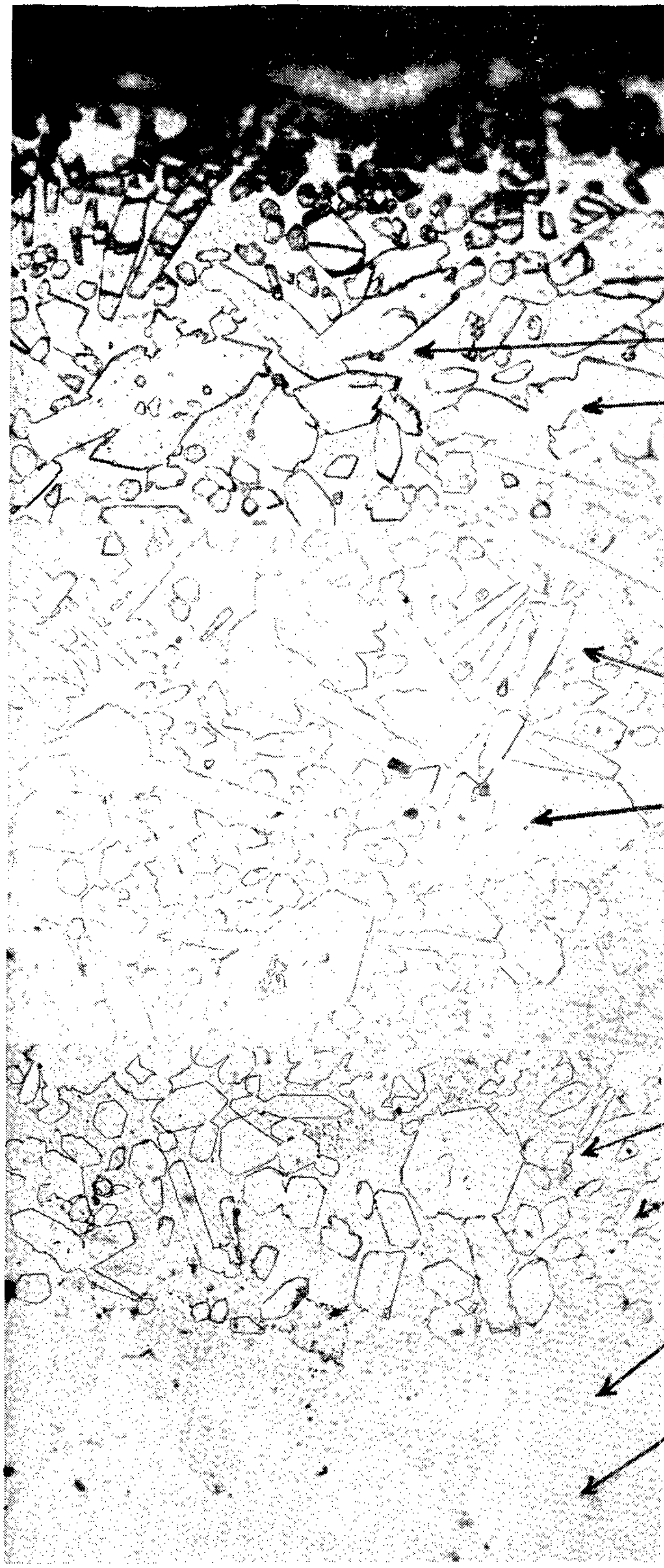
COATING THICKNESS

It should be noted that only company Code W705 maintained the coating thickness of .020" plus or minus .005" as specified on the purchase orders. The coating of Company Code C601 was more than double the specified thickness. The coating of company Code I6A varied greatly in thickness and the average thickness was at the very minimum specified.

The thinnest coating of any of the four lots was applied by company Code N with the average thickness being in the range of .012 - .014 inches.

After completion of the heat treating and machining, all shoes were shipped to Noblesville, Indiana for rubberizing and assembly into eight shoe pitches. Each lot was color coded and stamped for identification. All lots were accepted and shipped to TACOM for reshipment to Aberdeen Proving Ground for field testing. So ended Part II.

Code 601
Microstructure and Knoop Hardness Readings On
Hard Surface Overlay on Sprocket Window



Cross Section of Hard Surfacing
400X
Etch: $K_3Fe(CN)_6$/KOH Electrolytic

Matrix - 423 KHN
Carbide - 1810 KHN

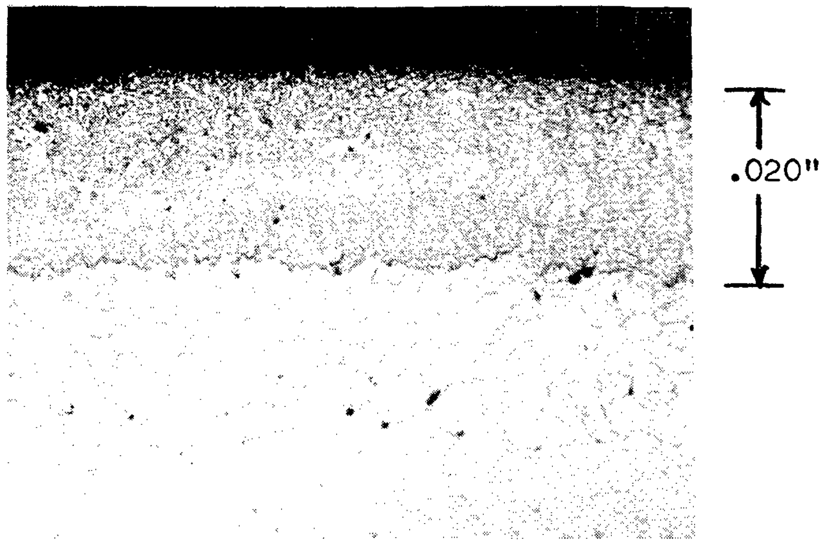
Matrix - 423 KHN
Carbide - 1810 KHN

Matrix - 423 KHN
Carbide - 1810 KHN

Base Metal - Alloyed Structure
(Massive Chromium Iron Carbides)
765 KHN

Alloyed Zone - Chromium Iron
193 KHN

Figure 1



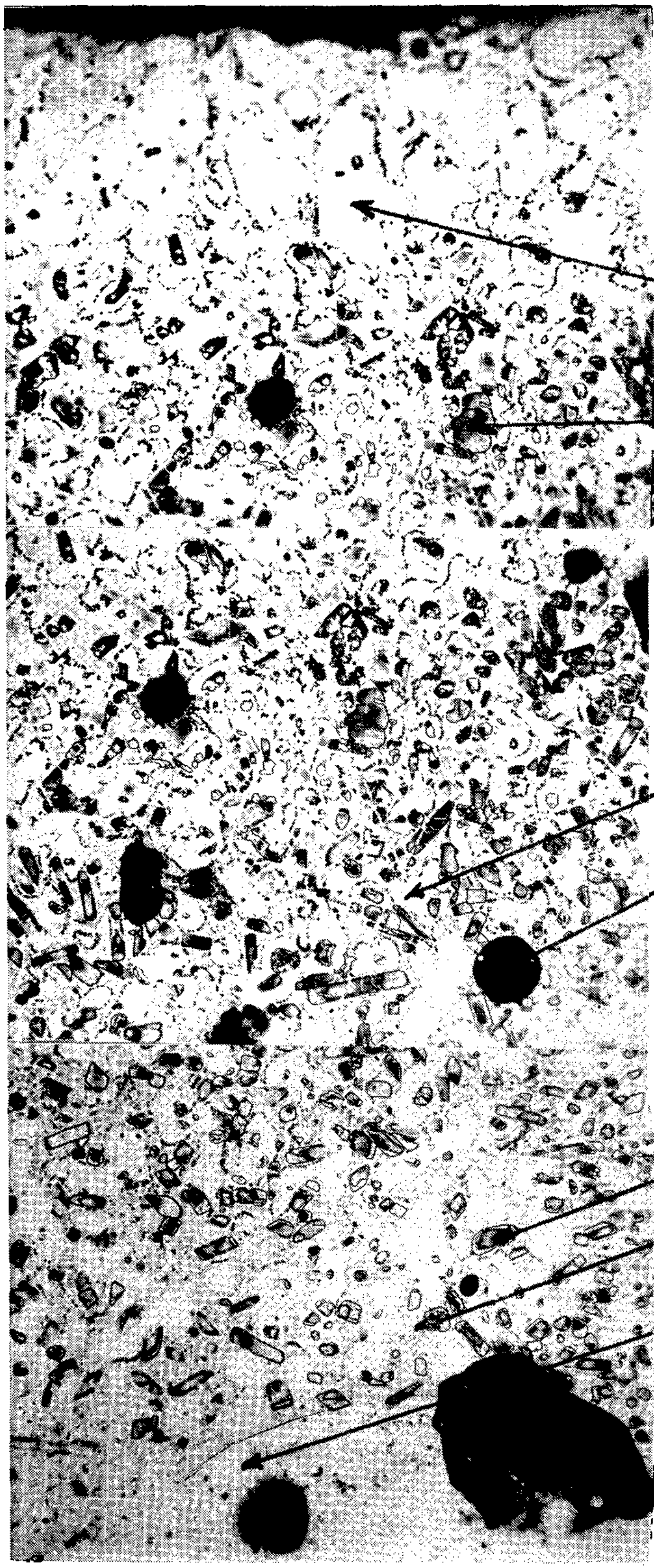
Code 601
50X

This shows a .020" thick deposit plus an alloyed zone in the 4140 base metal where the Chrome-Nickel-Boron brazing alloy has diffused to a depth of .020-.025". This diffusion zone has absorbed enough of the "high alloy" that it seems to be unaffected by the normalize, quench, and temper applied to the shoe. The porosity in this deposit is very low.

10% Potassium Ferricyanide Electrolytic Etch

Figure 2

Code I6A
Microstructure and Knoop Hardness Readings On
Hard Surface Overlay on Sprocket Window



Cross Section of Hard Surfacing
400X
Etch: $K_3Fe(CN)_6$/KOH Electrolytic

Carbide - 1120 KHN

Carbide - 1260 KHN

Carbide - 1260 KHN

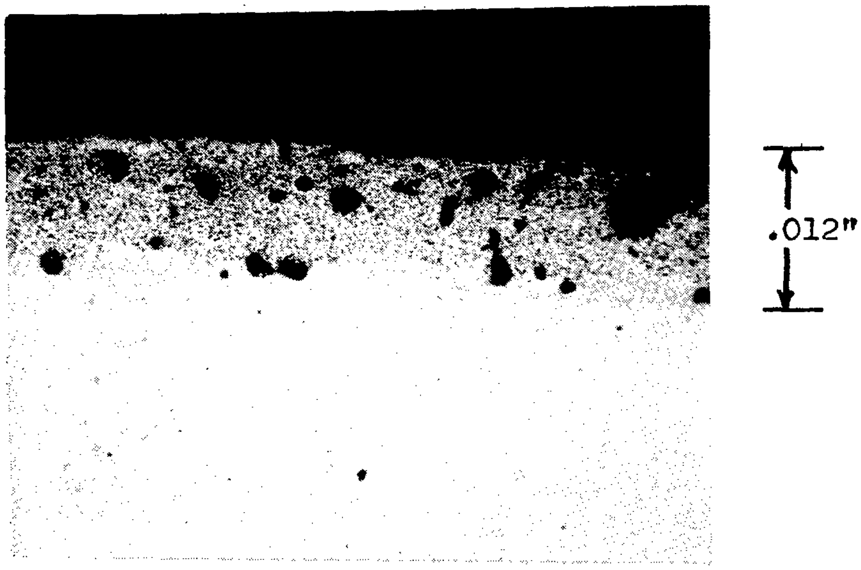
Void

Carbide - 1260 KHN

Matrix

Interface - 1080 KHN

Figure 3



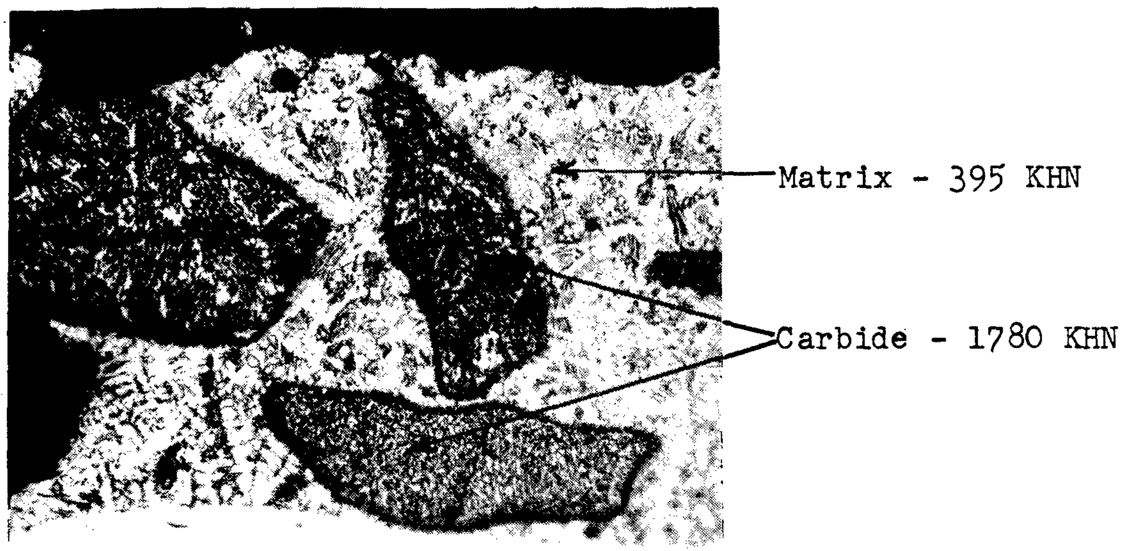
Code I6A
50X

This photo shows the .012" thick hard surface overlay with extensive porosity. These deposits have by far the largest amount of porosity of any of the four lots examined.

10% Potassium Ferricyanide Electrolytic Etch

Figure 4

Code N
Microstructure and Knoop Hardness Readings on
Hard Surface Overlay on Sprocket Window



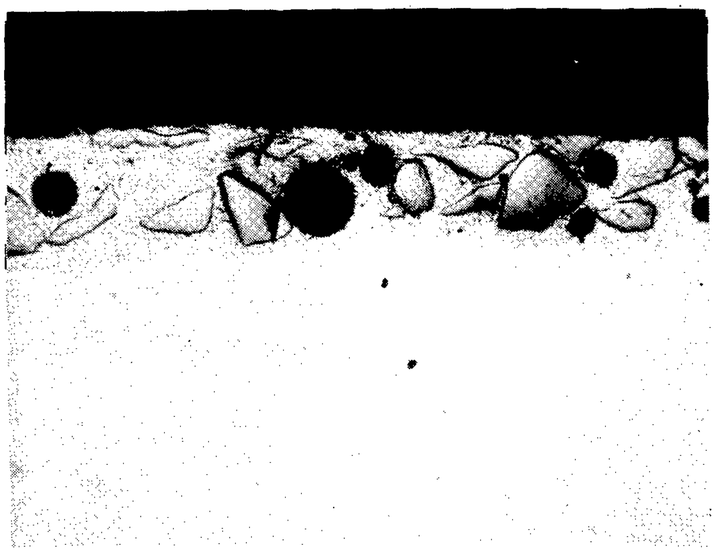
200X
Etch: $K_3Fe(CN)_6$/KOH Electrolytic

Figure 5

Code "N"
50X

This shows a .012" thick deposit with massive carbides in the matrix alloy.

10% Potassium Ferricyanide Electrolytic Etch

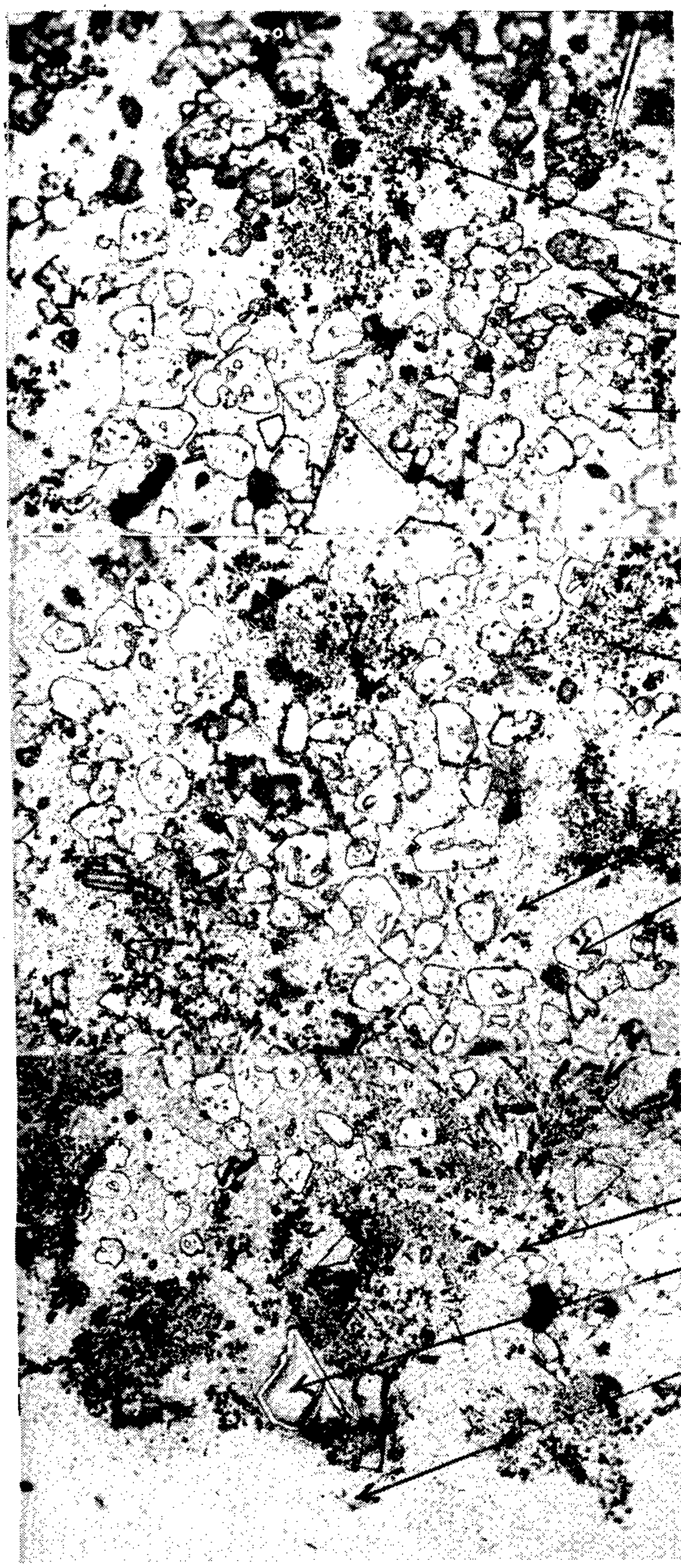


Code "N" Unetched
50X

This shows the massive carbides plus extensive gas porosity.

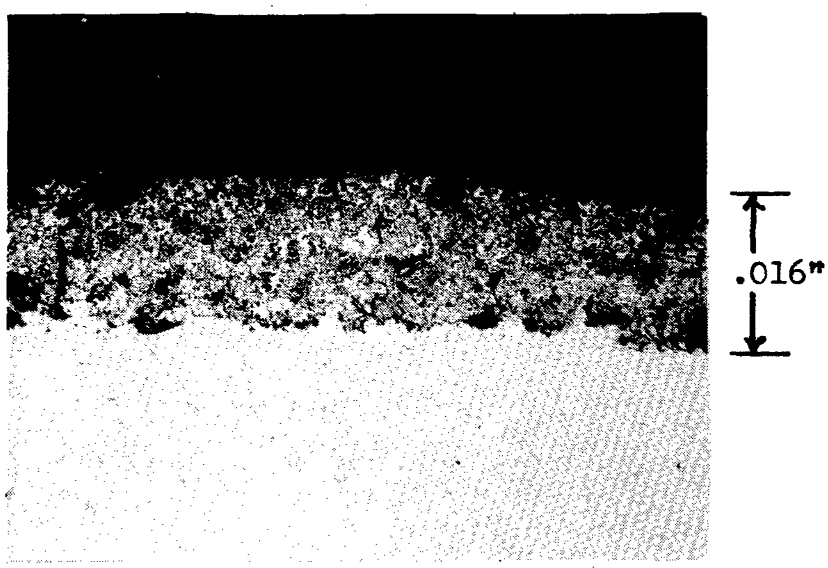
Figure 6

Code W705
Microstructure and Knoop Hardness Readings on
Hard Surface Overlay on Sprocket Window



Cross Section of Hard Surfacing
400X
Etch: $K_3Fe(CN)_6/KOH$ Electrolytic

Figure 7



Code W705
50X

This shows the .016" thick deposit with a moderate amount of porosity and/or inclusions.

10% Potassium Ferricyanide Electrolytic Etch

Figure 8

COATING THICKNESS SUMMARY

.020" ± .005" Specified

Vendor		Grouser	Sprocket Window	Center Guide
Code 601	*A.	.048"-.056"	.048"-.056"	.032"-.046"
	**B.	.048"-.056"	.048"-.056"	.040"-.048"
	Average	.052"	.052"	.041"
Code I6A	A.	.008"-.020"	.006"-.018"	.010"-.020"
	B.	.010"-.020"	.008"-.028"	.012"-.022"
	Average	.015"	.015"	.015"
Code N	A.	.012"-.018"	.010"-.020"	.008"-.014"
	B.	.004"-.012"	.008"-.020"	.008"-.016"
	Average	.012"	.014"	.012"
Code W705	A.	.014"-.028"	.016"-.032"	.018"-.026"
	B.	.004"-.032"	.014"-.028"	.018"-.032"
	Average	.022"	.022"	.023"

*A - Unmachined Shoe
**B - Machined Shoe

Table 2

PART III

1. FIELD TESTING

The four lots of T130 track shoes were field tested at two separate locations. One test was conducted at Aberdeen Proving Ground, Aberdeen, Maryland and the second at Yuma Proving Ground, Yuma, Arizona. The full final reports from both of these proving grounds are contained in the appendix. The summary below is based on this test data as well as observations made during trips to Aberdeen on September 21, 1972, and to Yuma on October 16, 1972.

A. Aberdeen Test Summary

1) All shoes that had to be replaced during the test were replaced because of rubber bushing failures and not because of metal failures.

2) At the end of 6,000 miles all shoes in which the bushings had not failed were still operable, but all four of the different hard surface coatings had been penetrated.

3) No fatigue cracks had developed adjacent to the hard surfaced areas. Fatigue cracking adjacent to induction hardened areas was stated as a common cause of track shoe failures in normal service.

4) Eight sample shoes were selected (two from each of the hard surfacing processes) for shipment to code FML for metallurgical examination.

B. Yuma Test Summary

1) The experience at Yuma was similar to the results obtained at Aberdeen. Shoe failures were primarily the result of rubber bushing failures rather than metal failures.

2) Eight shoes from Yuma were also returned to Code FML for metallurgical examination.

The data compiled from the metallurgical examination of the tested track shoes is listed in Table 3.

2. EXAMINATION OF FIELD TESTED SHOES

A. In all cases the grousers showed the greatest wear, with the sprocket window next and the center guide the least.

B. In all cases, after 2,929 miles, the grousers showed a wear loss of 11/32-13/32 inch which indicates the hard surface overlay was worn through after some 1,000 miles of service. After approximately 1,000 miles of service, the rate of wear was a function of the wear resistance of the quenched and tempered steel at a hardness of 30 Rockwell C.

C. In comparing the amount of wear between the four lots of shoes, no significant difference was found.

D. Induction hardened shoes exhibited grouser and center-guide wear areas having as much wear as hard surfaced shoes at the same mileage, although there was less wear in the sprocket window of induction hardened shoes compared to hard surfaced shoes.

E. Figures 9 through 36 show section samples of track shoes before and during testing and after completion of testing.

3. SUMMARY OF FIELD TESTING

A. The examination of the shoes after field testing for between 2,900 and 6,000 miles revealed little difference in the rate of wear between the four different hard surfacing systems. All the hard coatings were penetrated at around 1,000 miles. After penetration the rate of wear of the base metal was fairly uniform at between 4/32 and 6/32 per 1,000 miles for the grousers and 3/32 to 5/32 per 1,000 miles for the sprocket windows.

FIELD TEST SUMMARY

Vendor	Shoe	Mileage	Proving Ground	Approximate Total Wear: Center Guide	Grousers	Sprocket Window
Code 601	C3	2,929	Y*	1/32"	13/32"	7/32"
	C4	3,563	Y	1/32"	15/32"	7/32"
	C74	3,933	A**	2/32"	18/32"	10/32"
	C75	6,016	A	3/32"	19/32"	13/32"
Code I6A	I1	2,929	Y	1/32"	11/32"	6/32"
	I4	3,563	Y	2/32"	15/32"	7/32"
	I60	3,933	A	3/32"	17/32"	11/32"
	I6	5,367	A	3/32"	21/32"	9/32"
Code N	N1	2,929	Y	1/32"	13/32"	7/32"
	N9	3,563	Y	2/32"	14/32"	8/32"
	N71	3,933	A	3/32"	17/32"	9/32"
	N21	5,367	A	4/32"	21/32"	11/32"
Code W705	W7	2,929	Y	1/32"	11/32"	3/32"
	W1	3,563	Y	1/32"	15/32"	5/32"
	W90	3,933	A	2/32"	17/32"	8/32"
	W42	5,367	A	3/32"	19/32"	9/32"
Induction Hardened Shoe	H1	6,016	A	3/32"	21/32"	6/32"

*Yuma, Arizona
**Aberdeen, Maryland

Table 3

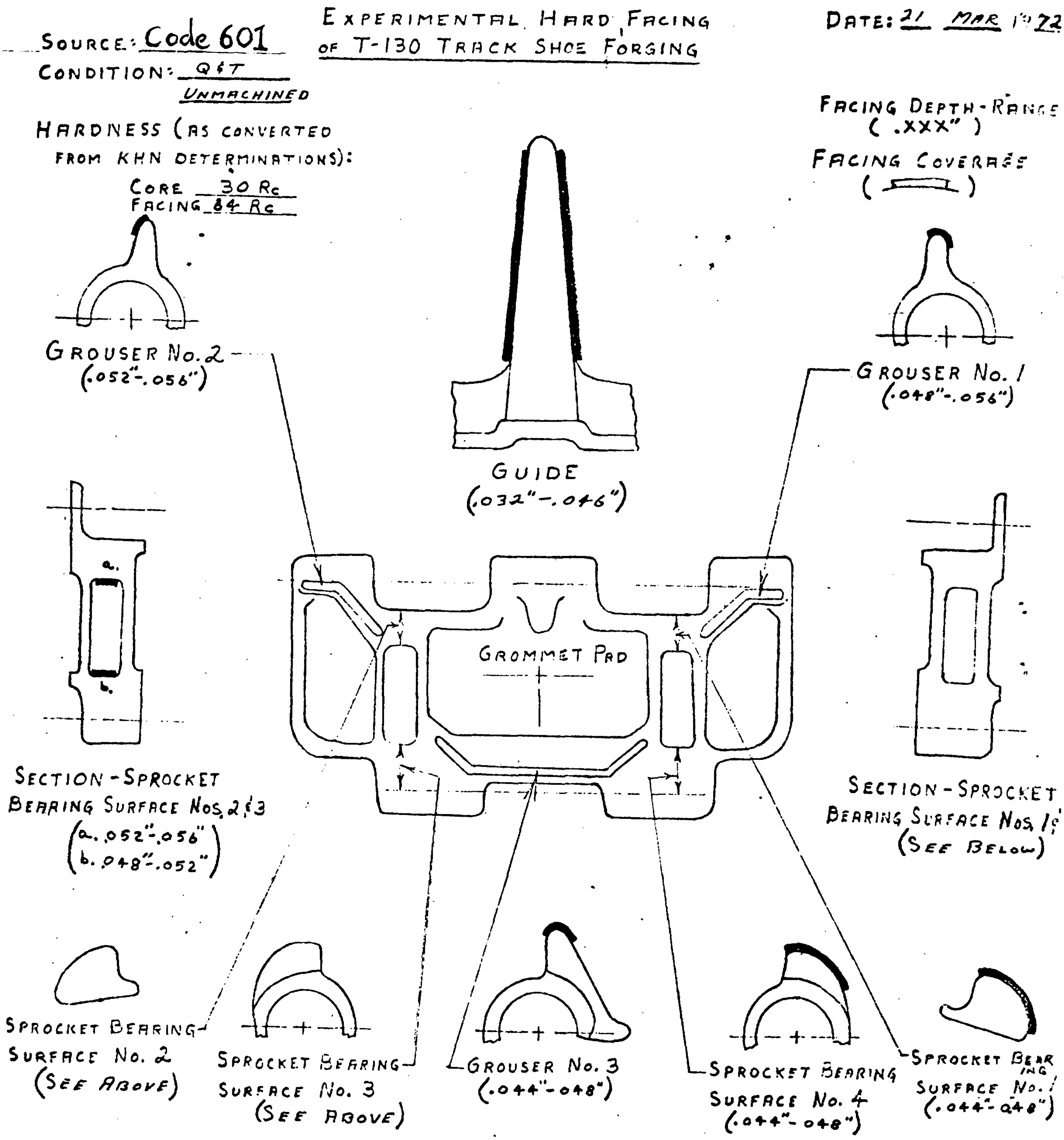


Figure 9

SECTIONED BEFORE MACHINING

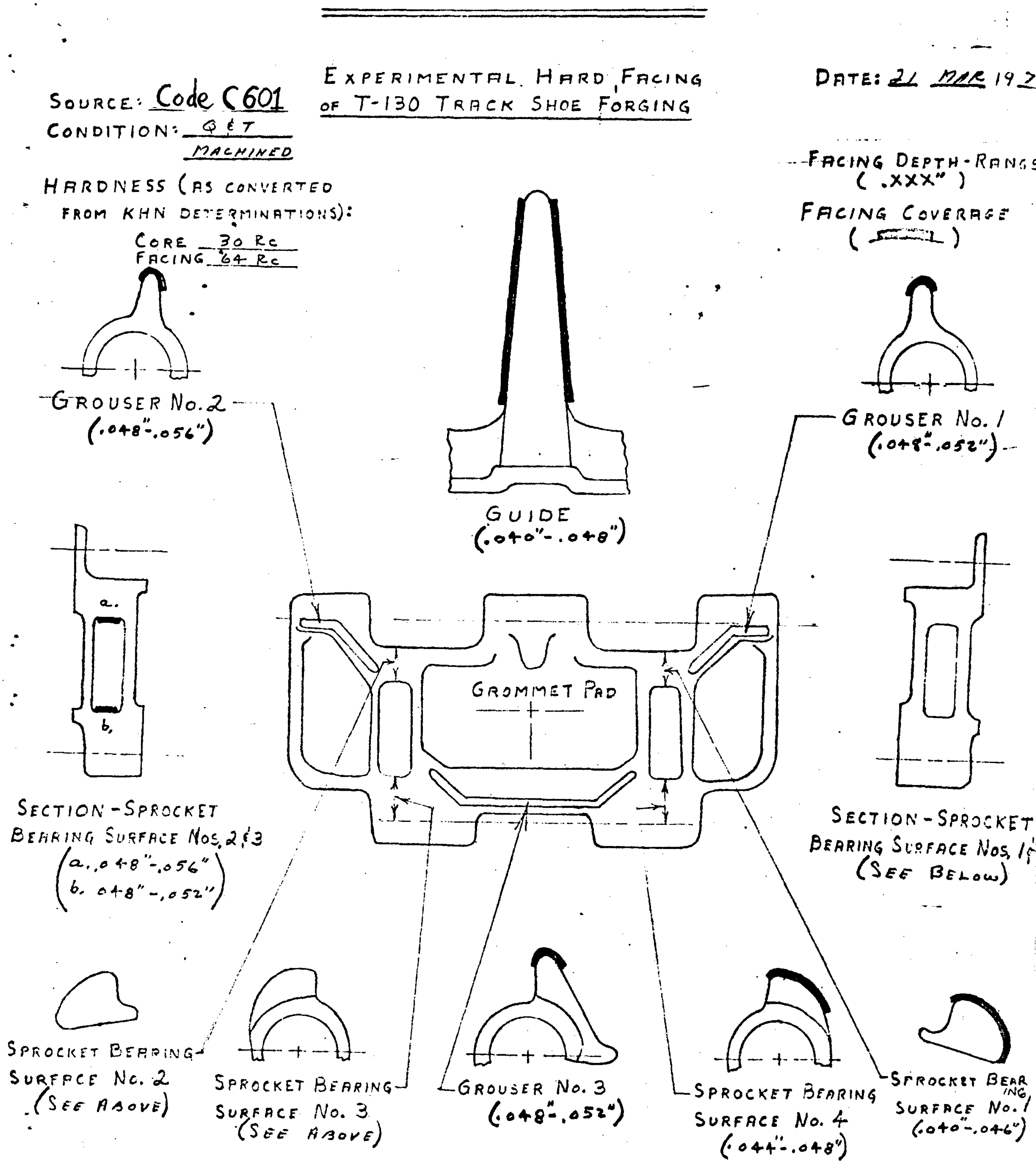
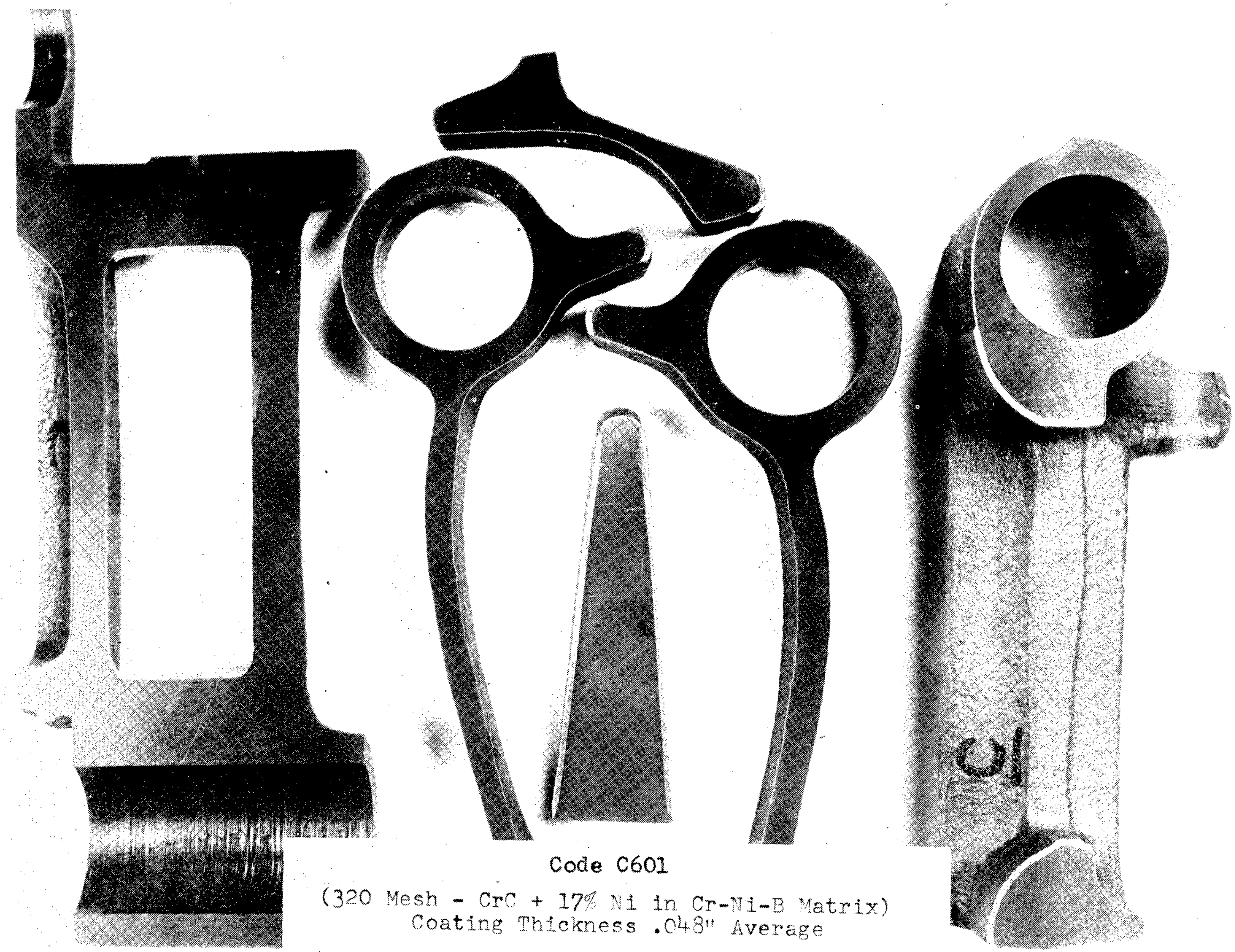


Figure 10

SECTIONED AFTER MACHINING



Code C601

(320 Mesh - CrC + 17% Ni in Cr-Ni-B Matrix)
Coating Thickness .048" Average

Figure 11 Before Field Test

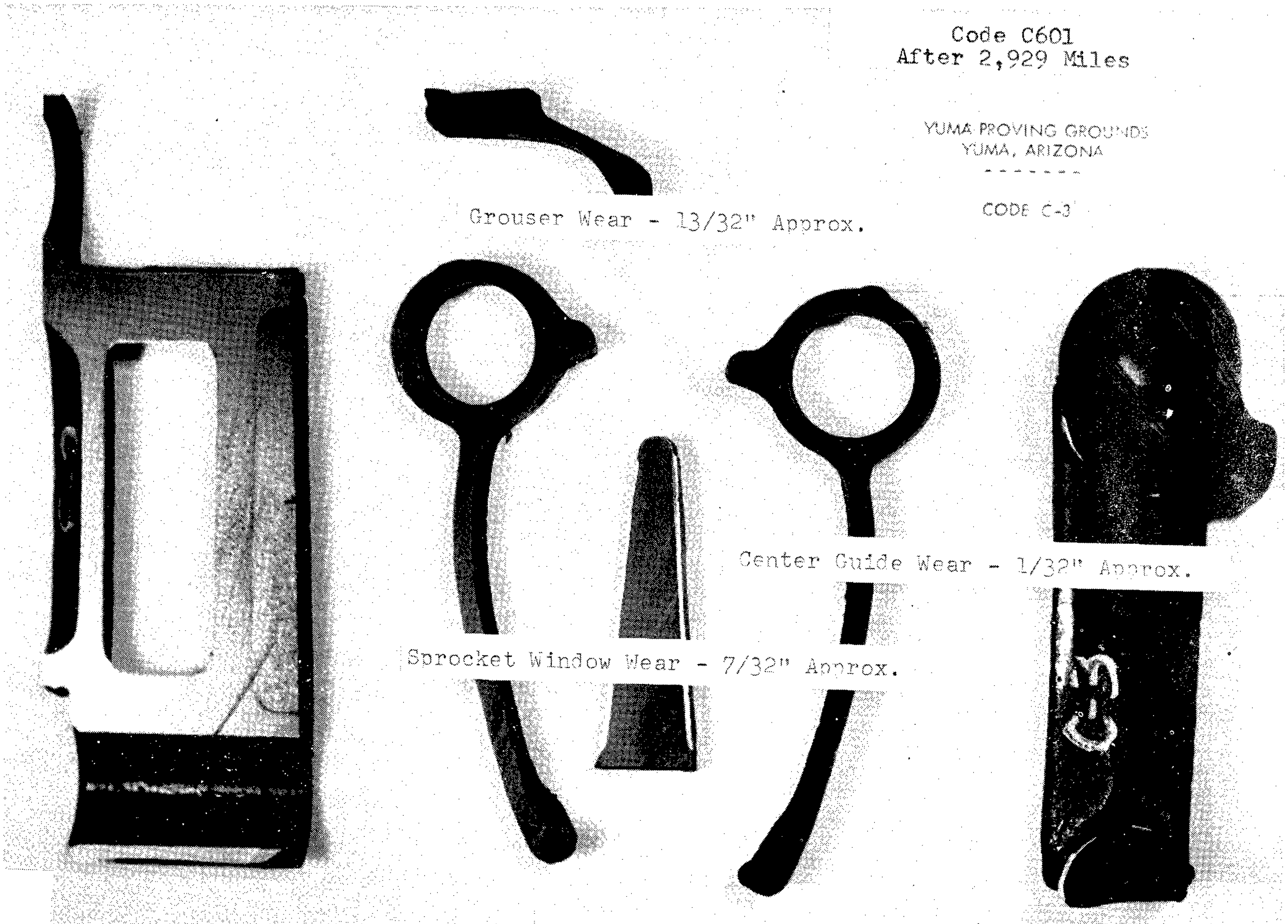

Code C601
After 2,929 Miles
YUMA PROVING GROUNDS
YUMA, ARIZONA
CODE C-3
Grouser Wear - 13/32" Approx.
Center Guide Wear - 1/32" Approx.
Sprocket Window Wear - 7/32" Approx.

Figure 12

Code C601
After 3,563 Miles

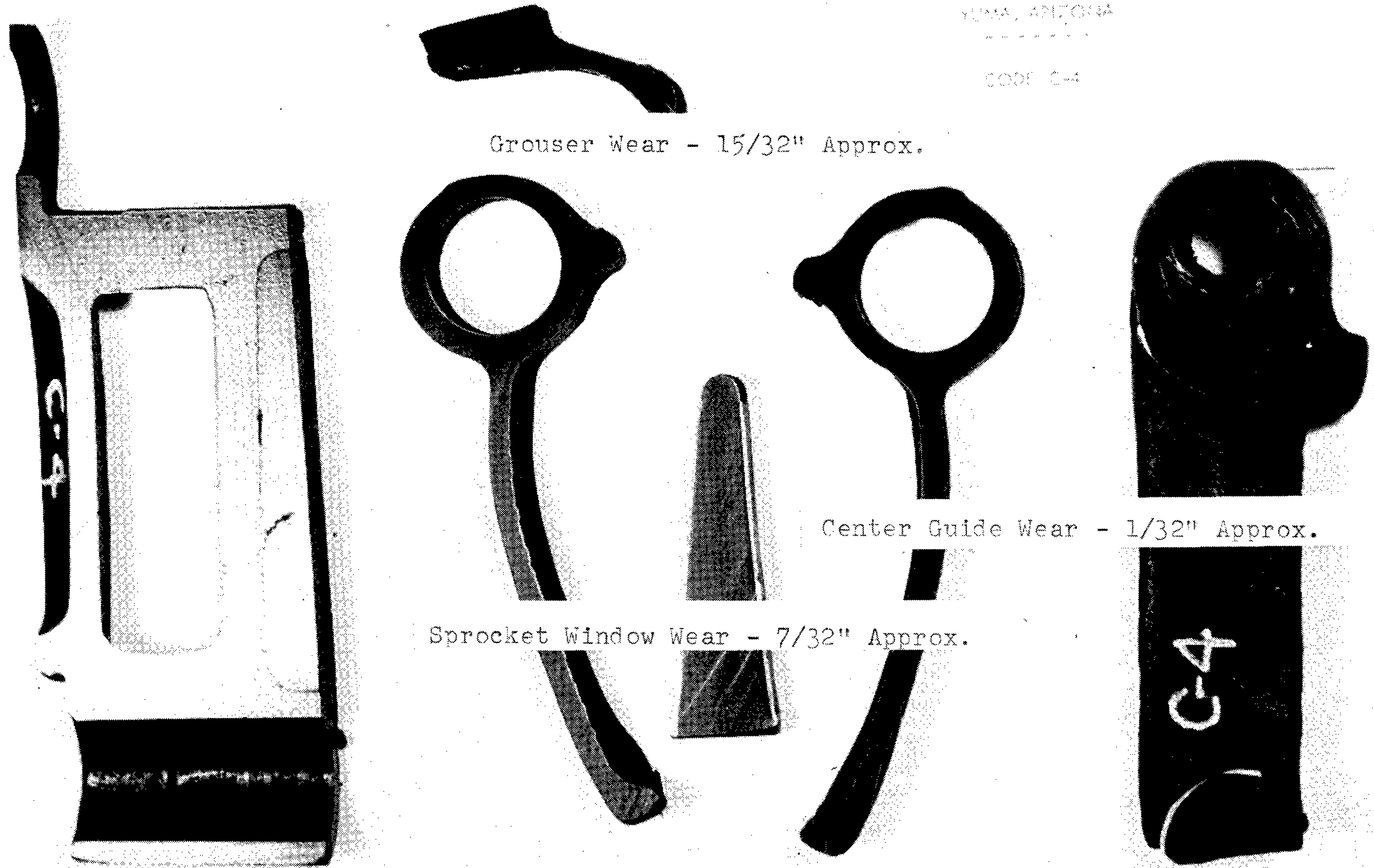


Figure 13

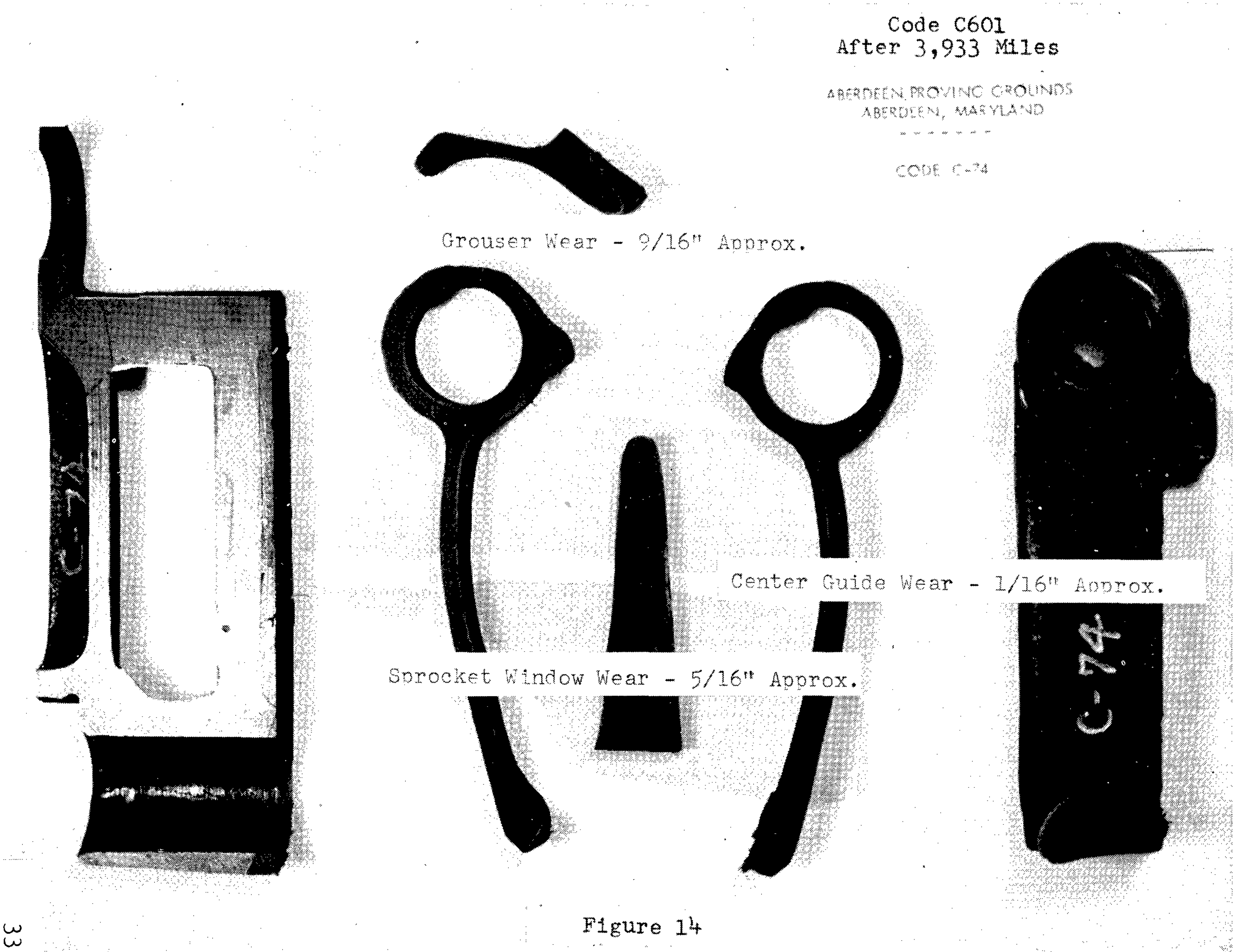

Code C601
After 3,933 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE C-74
Grouser Wear - 9/16" Approx.
Center Guide Wear - 1/16" Approx.
Sprocket Window Wear - 5/16" Approx.
C-74

Figure 14

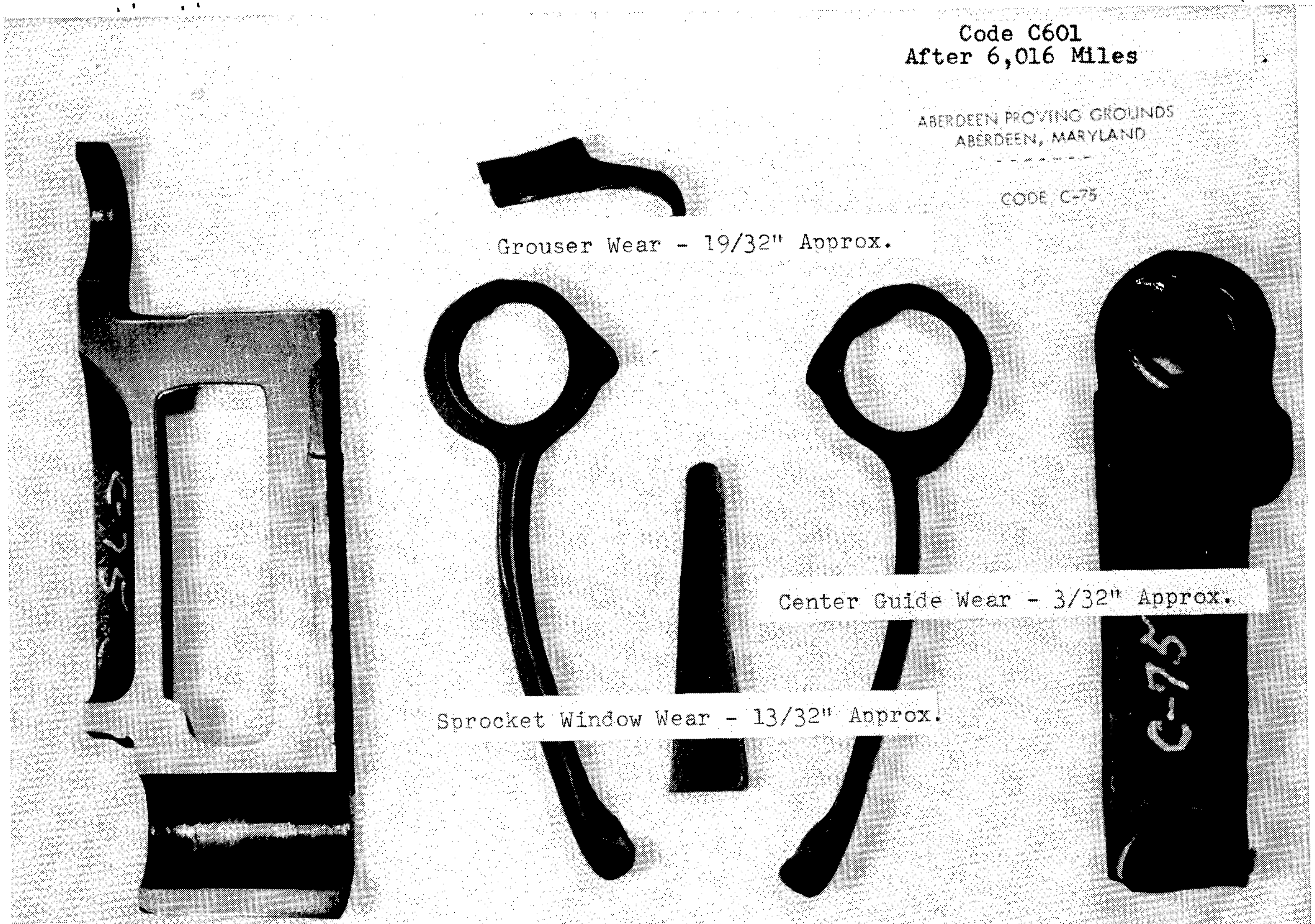

Code C601
After 6,016 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE C-75
Grouser Wear - 19/32" Approx.
Center Guide Wear - 3/32" Approx.
Sprocket Window Wear - 13/32" Approx.
C-75
C-75

Figure 15

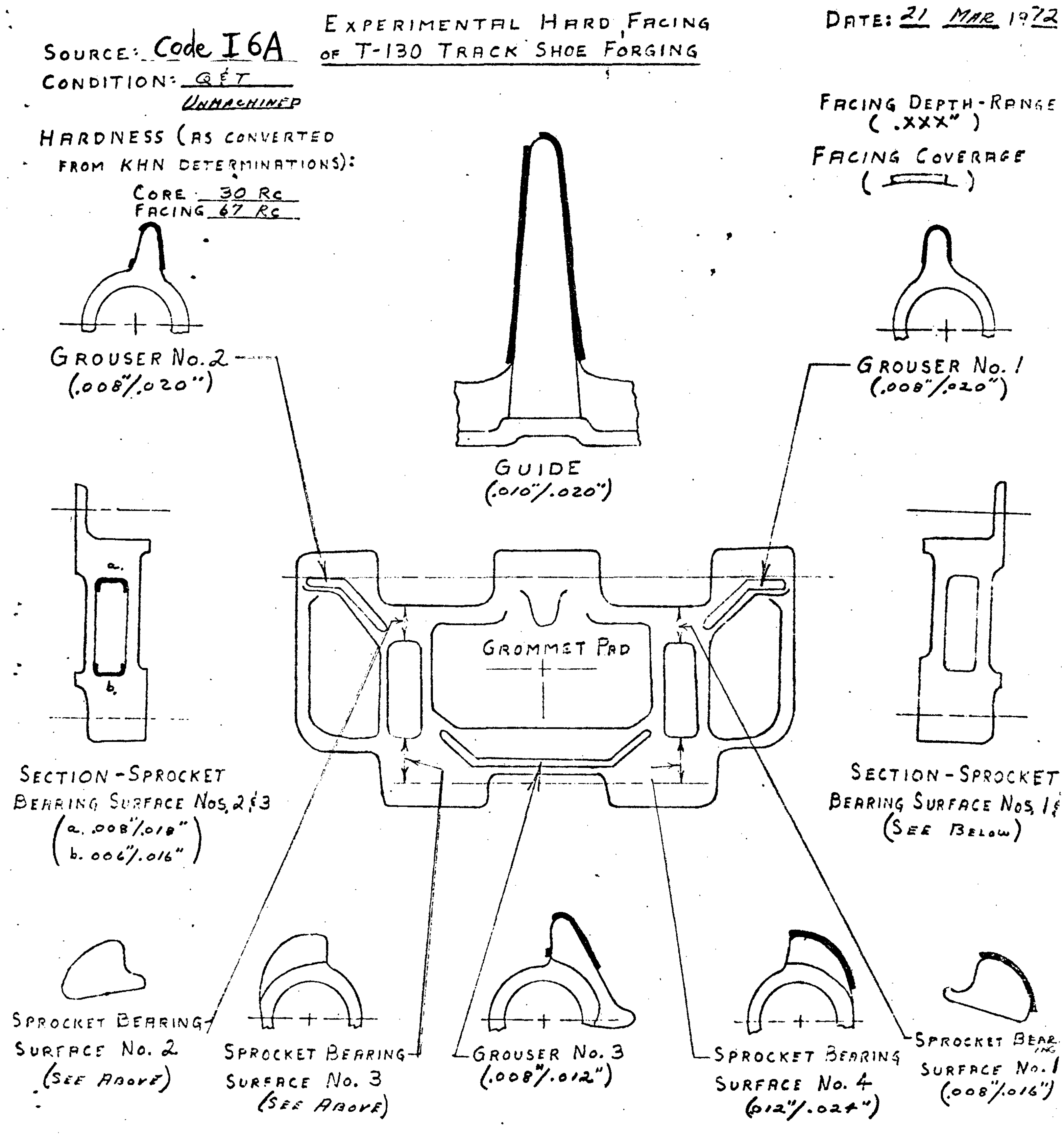


Figure 16

SECTIONED BEFORE MACHINING

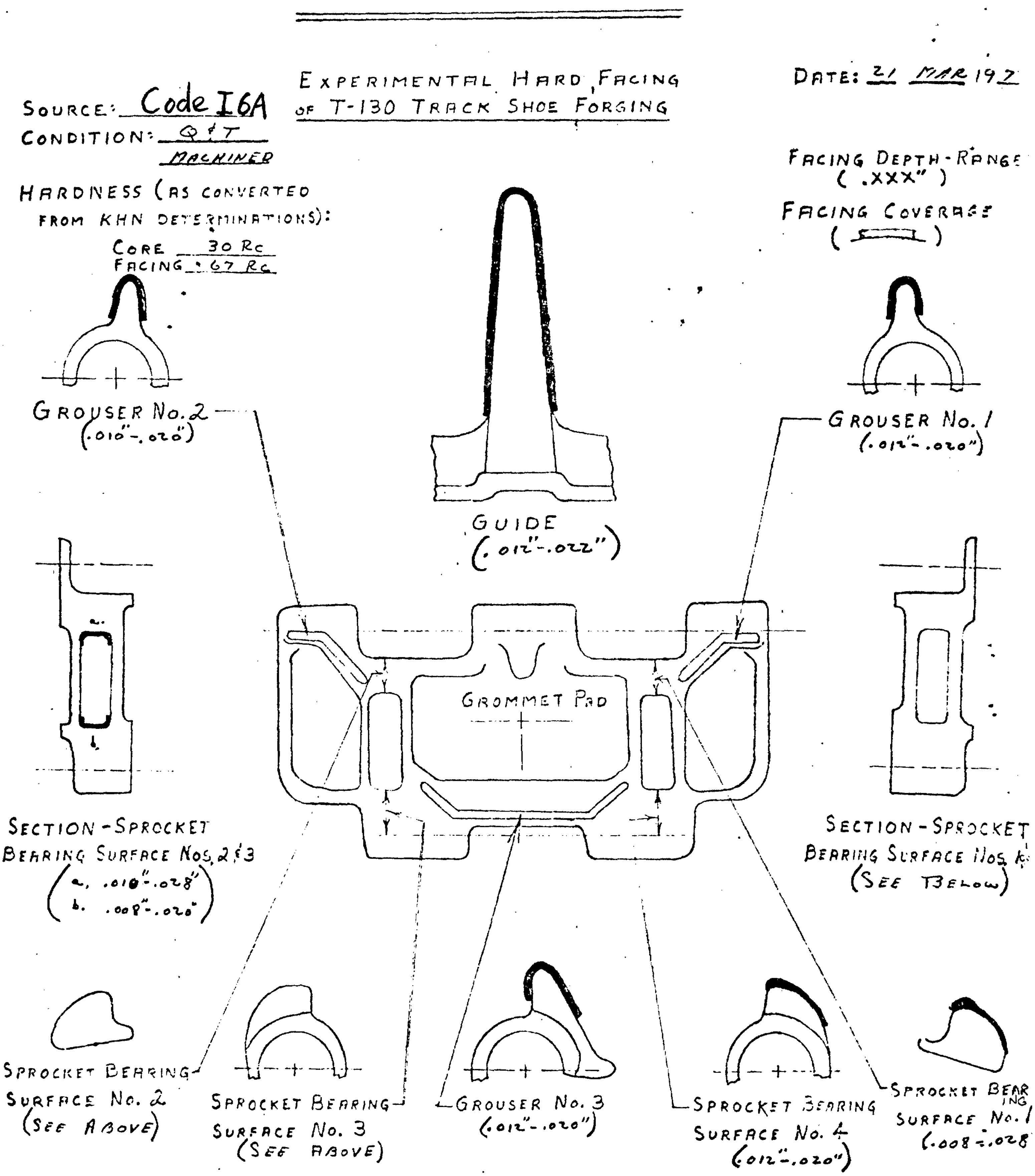
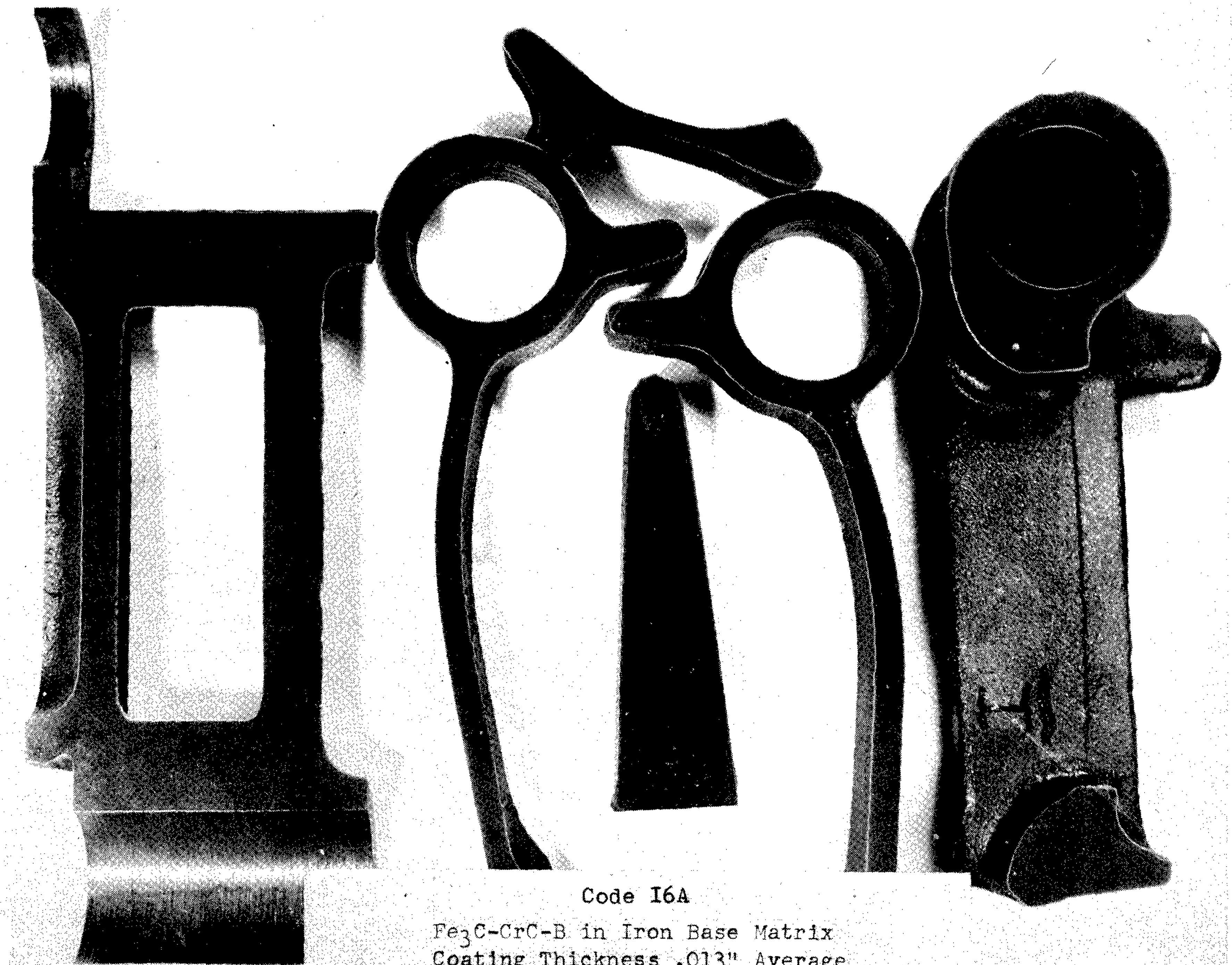


Figure 17

SECTIONED AFTER MACHINING



Code I6A

Fe_3C-CrC-B in Iron Base Matrix
Coating Thickness .013" Average

Figure 18 Before Field Test

Code I6A
After 2,929 Miles

YUMA PROVING GROUNDS
YUMA, ARIZONA

CODE I-I

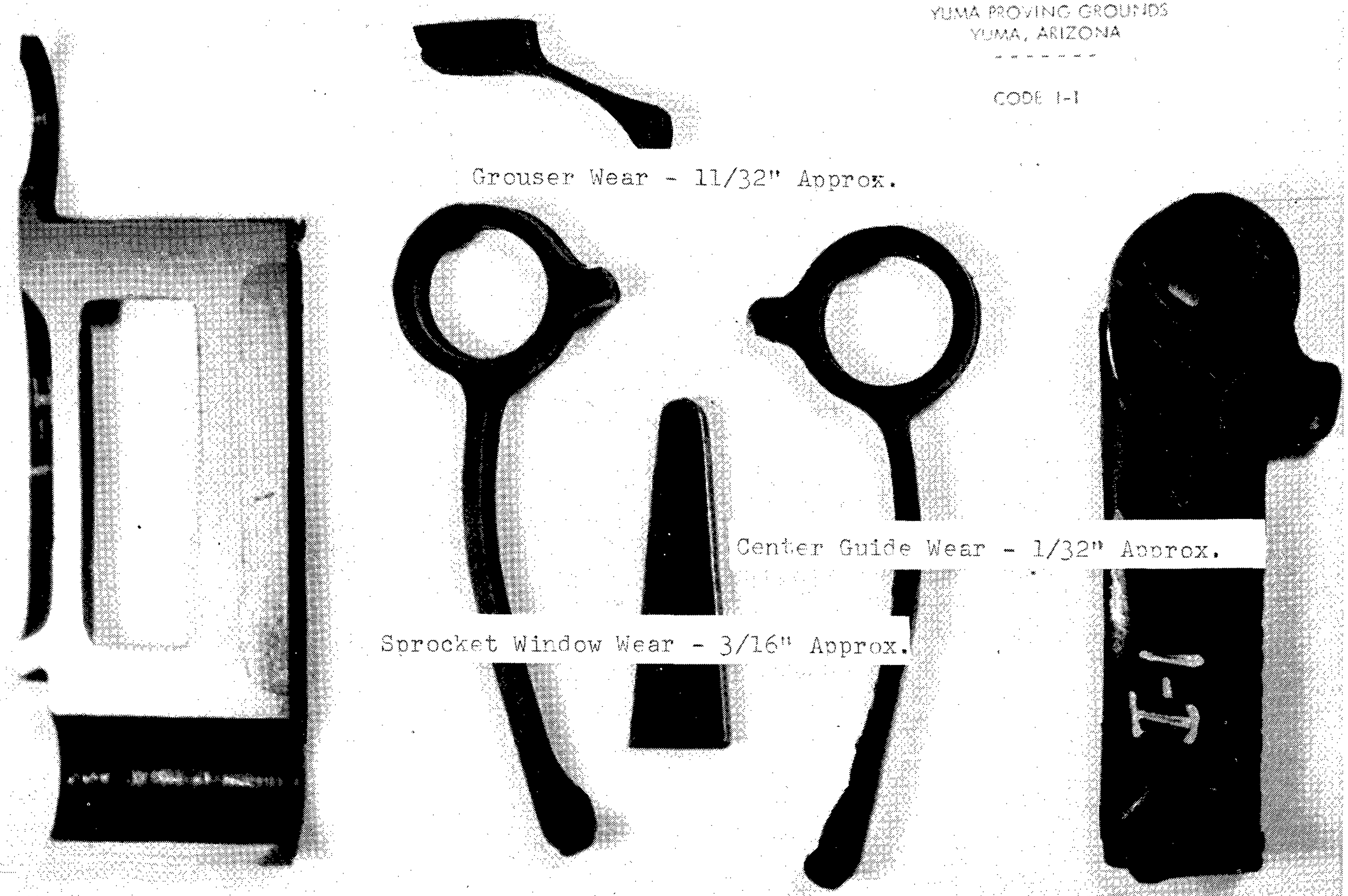


Figure 19

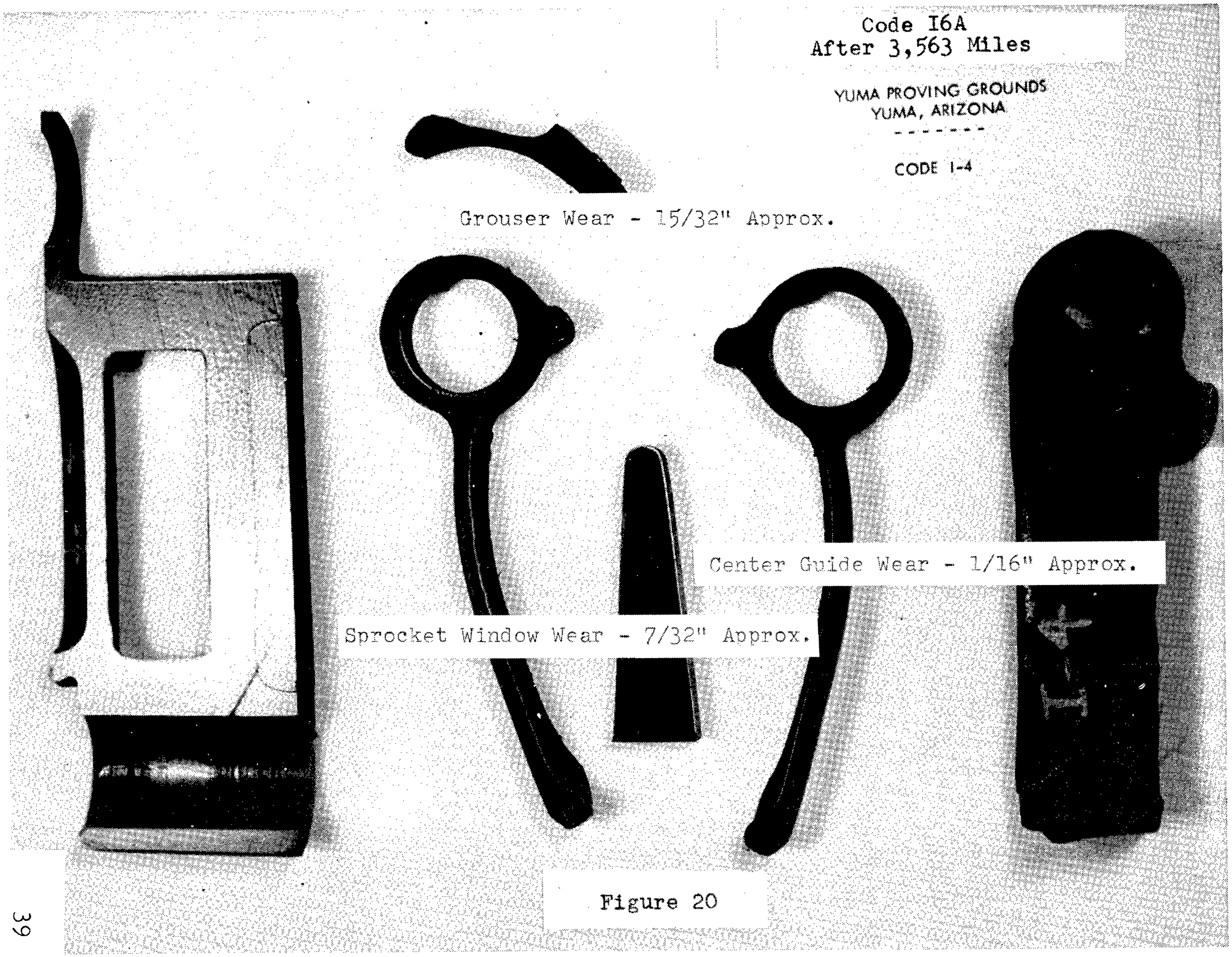

Code I6A
After 3,563 Miles
YUMA PROVING GROUNDS
YUMA, ARIZONA
CODE I-4
Grouser Wear - 15/32" Approx.
Center Guide Wear - 1/16" Approx.
Sprocket Window Wear - 7/32" Approx.

Figure 20

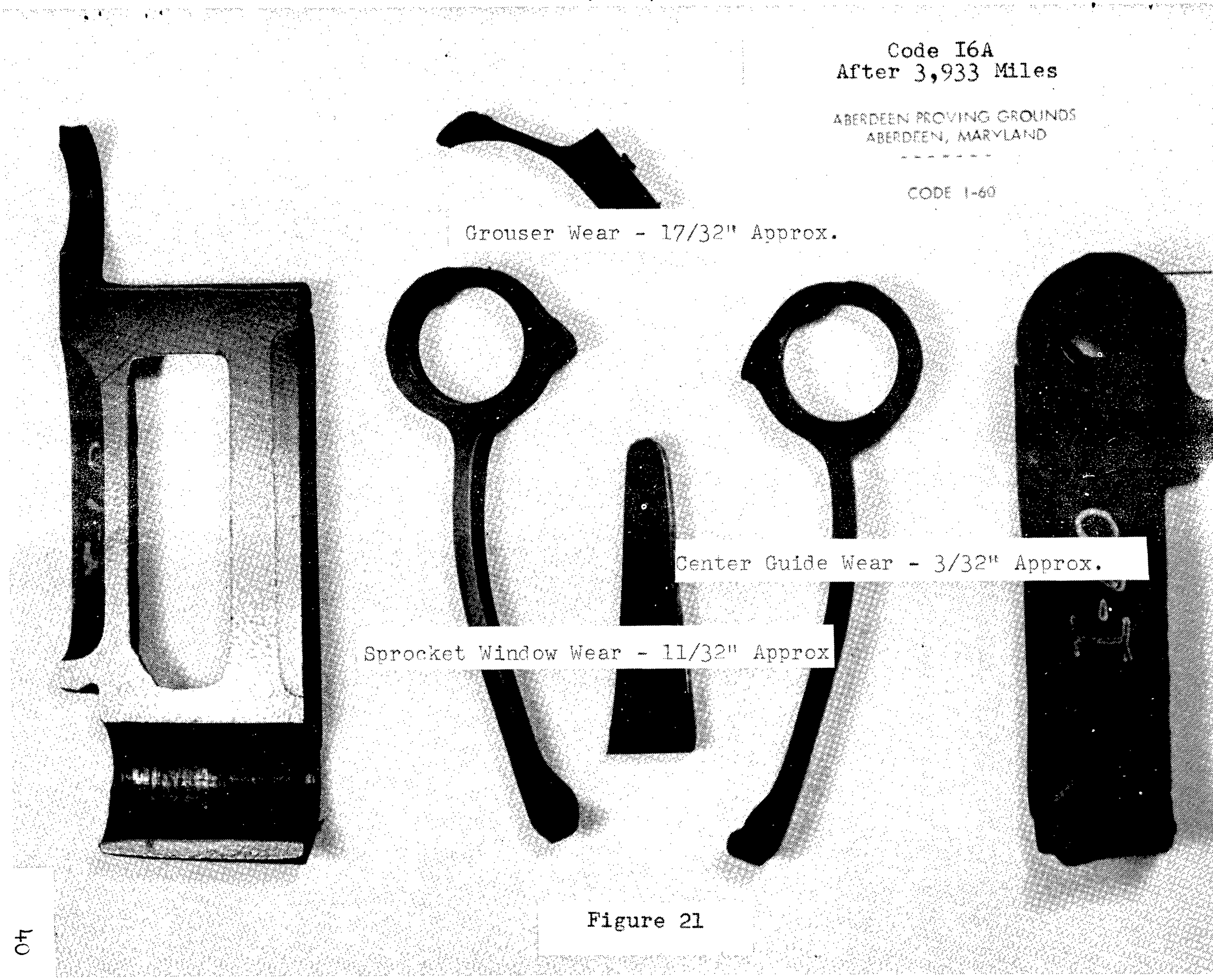

Code I6A
After 3,933 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE 1-60
Grouser Wear - 17/32" Approx.
Center Guide Wear - 3/32" Approx.
Sprocket Window Wear - 11/32" Approx

Figure 21

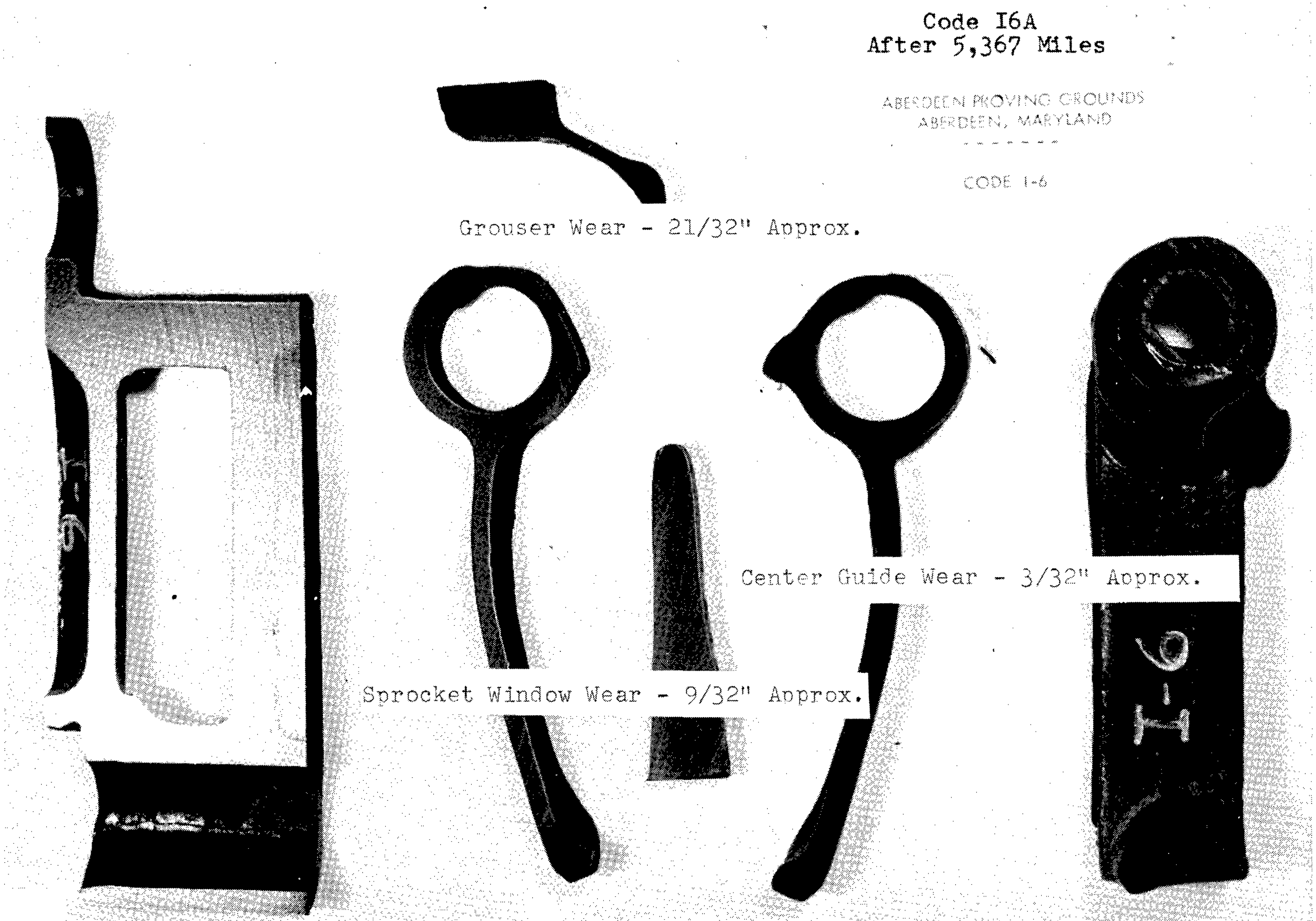

Code I6A
After 5,367 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE I-6
Grouser Wear - 21/32" Approx.
Center Guide Wear - 3/32" Approx.
Sprocket Window Wear - 9/32" Approx.
I-6

Figure 22

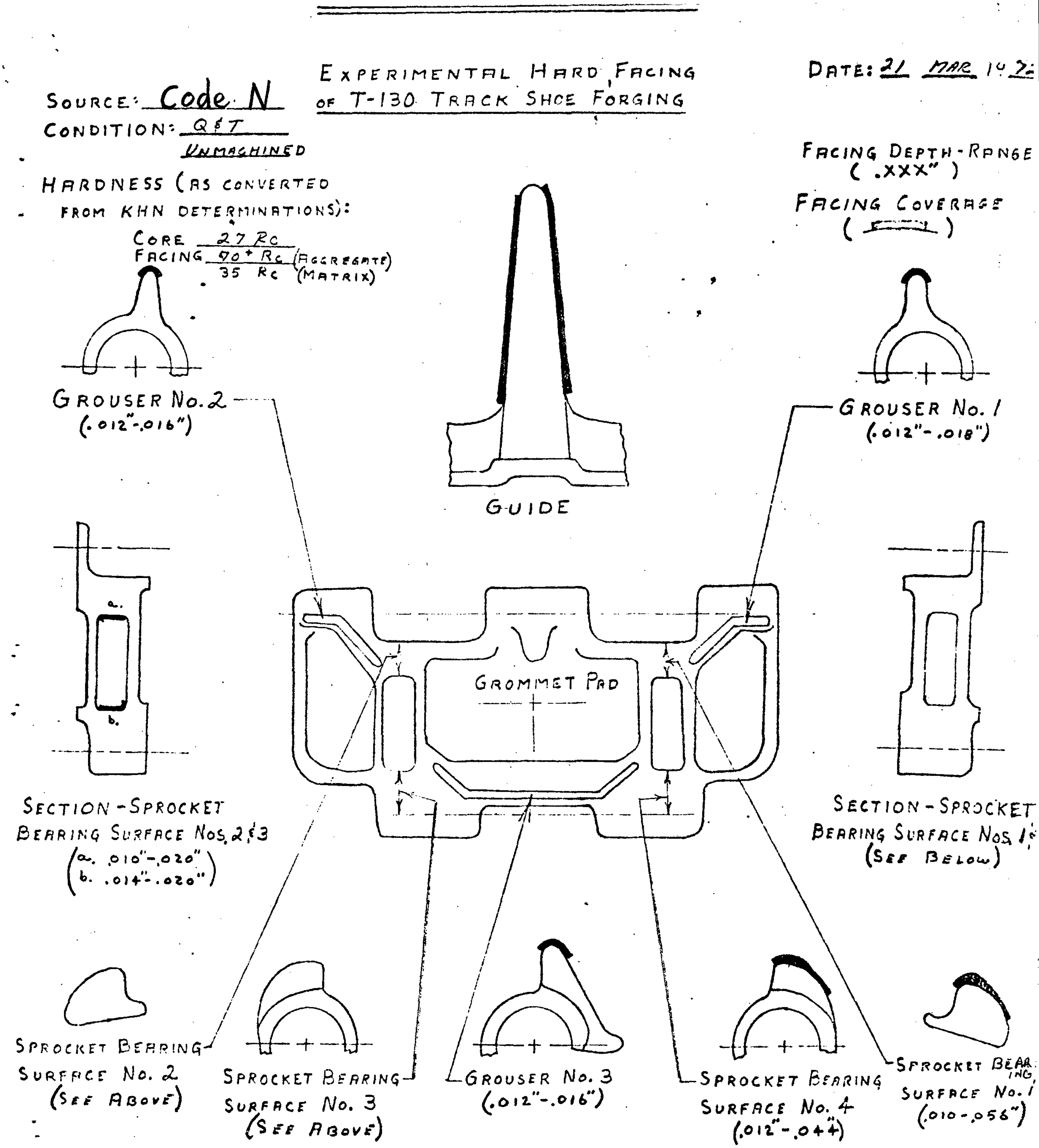


Figure 23

SECTIONED BEFORE MACHINING

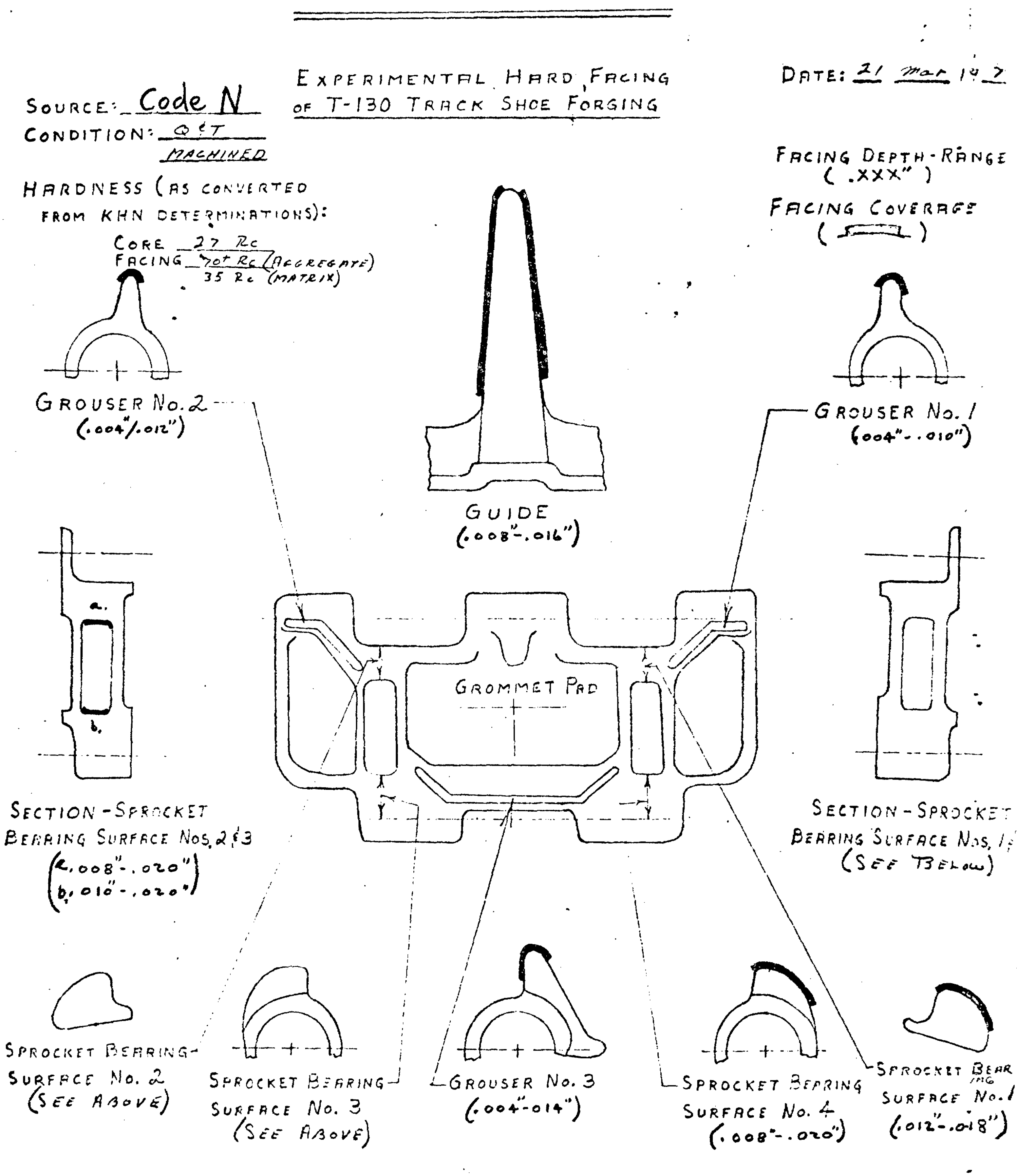
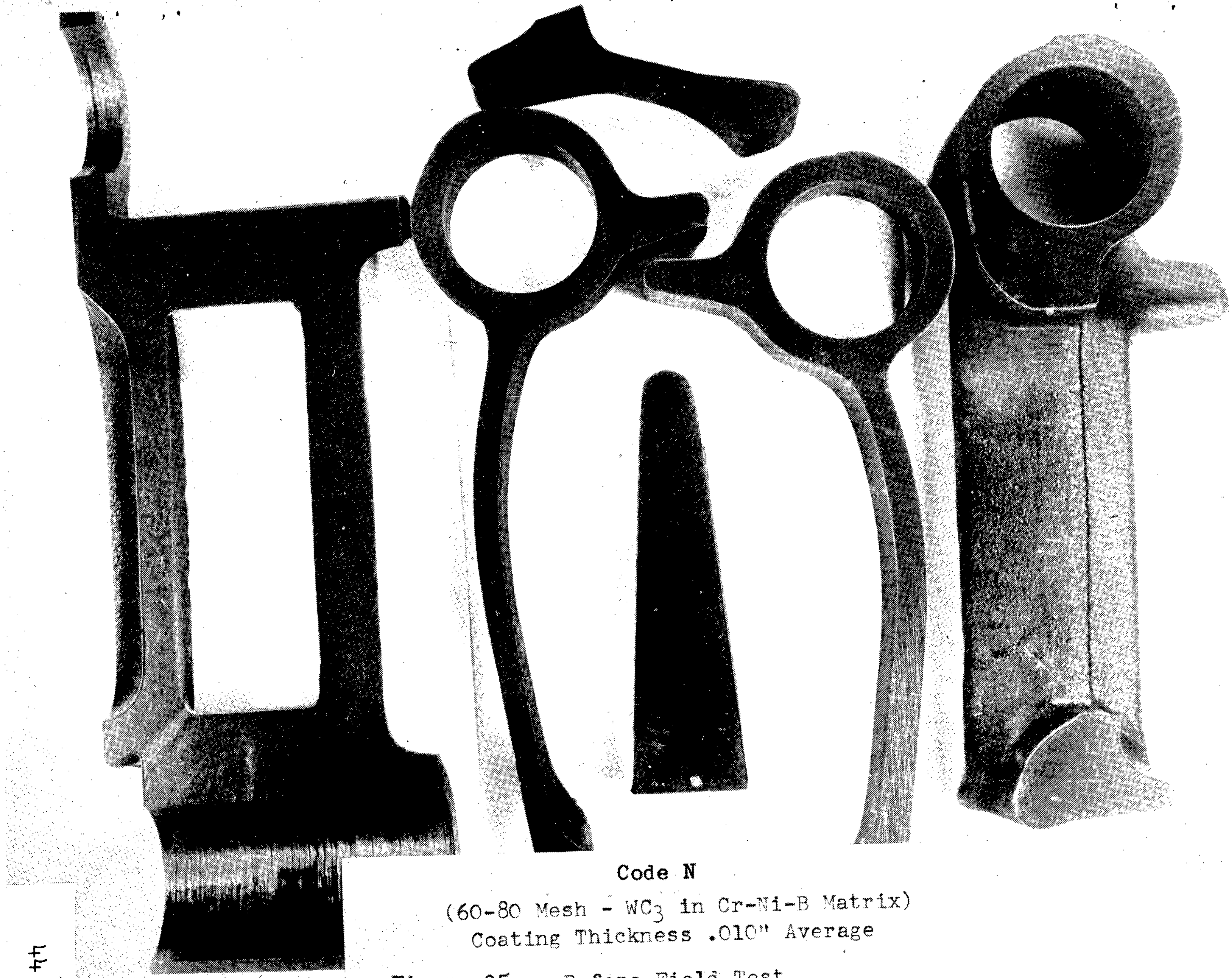


Figure 24

SECTIONED AFTER MACHINING



Code N

(60-80 Mesh - WC_3 in Cr-Ni-B Matrix)
Coating Thickness .010" Average

Figure 25 Before Field Test

Code N
After 2,929 Miles

YUMA PROVING GROUNDS
YUMA, ARIZONA

CODE N-1

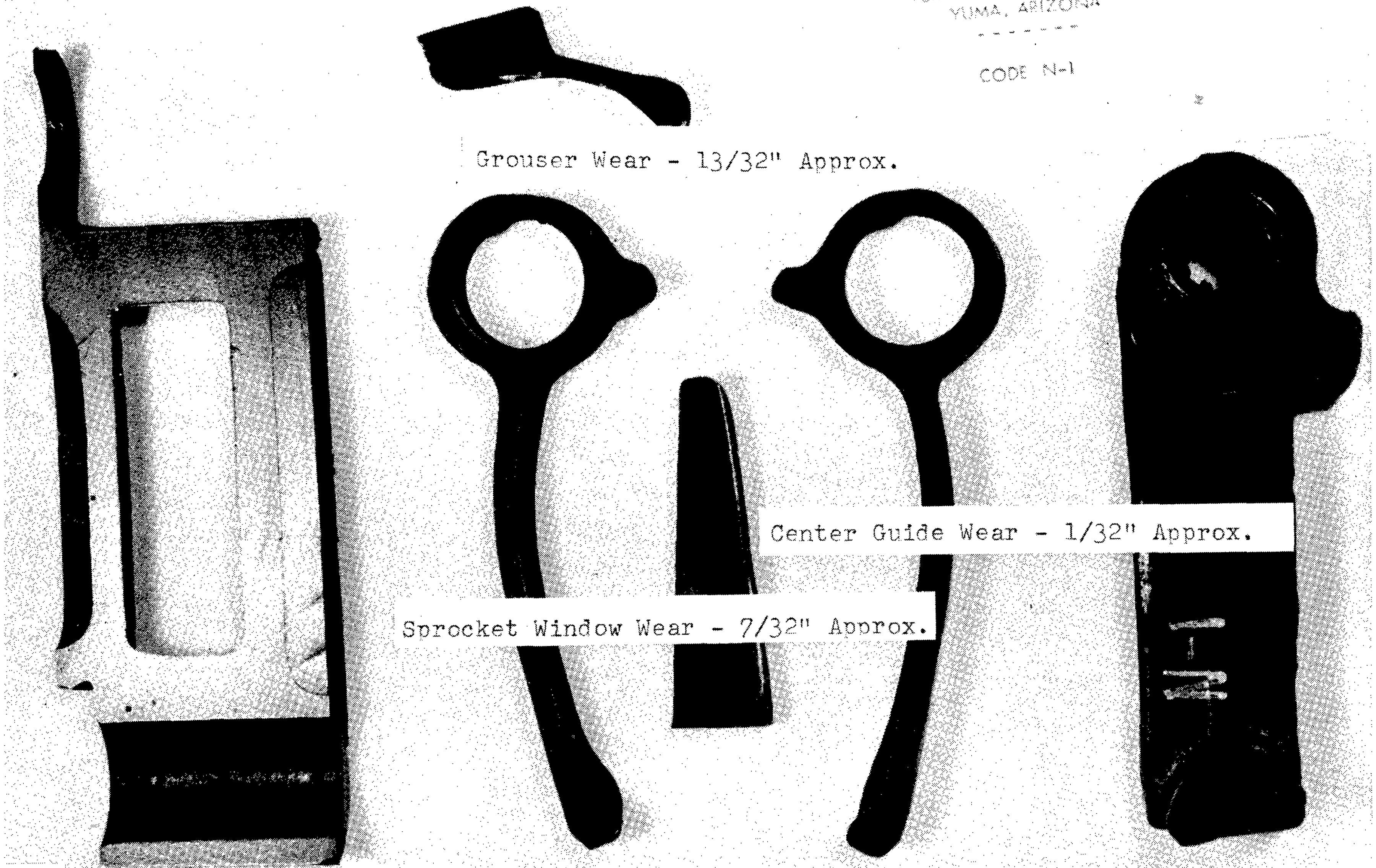


Figure 26

Code N
After 3,563 Miles

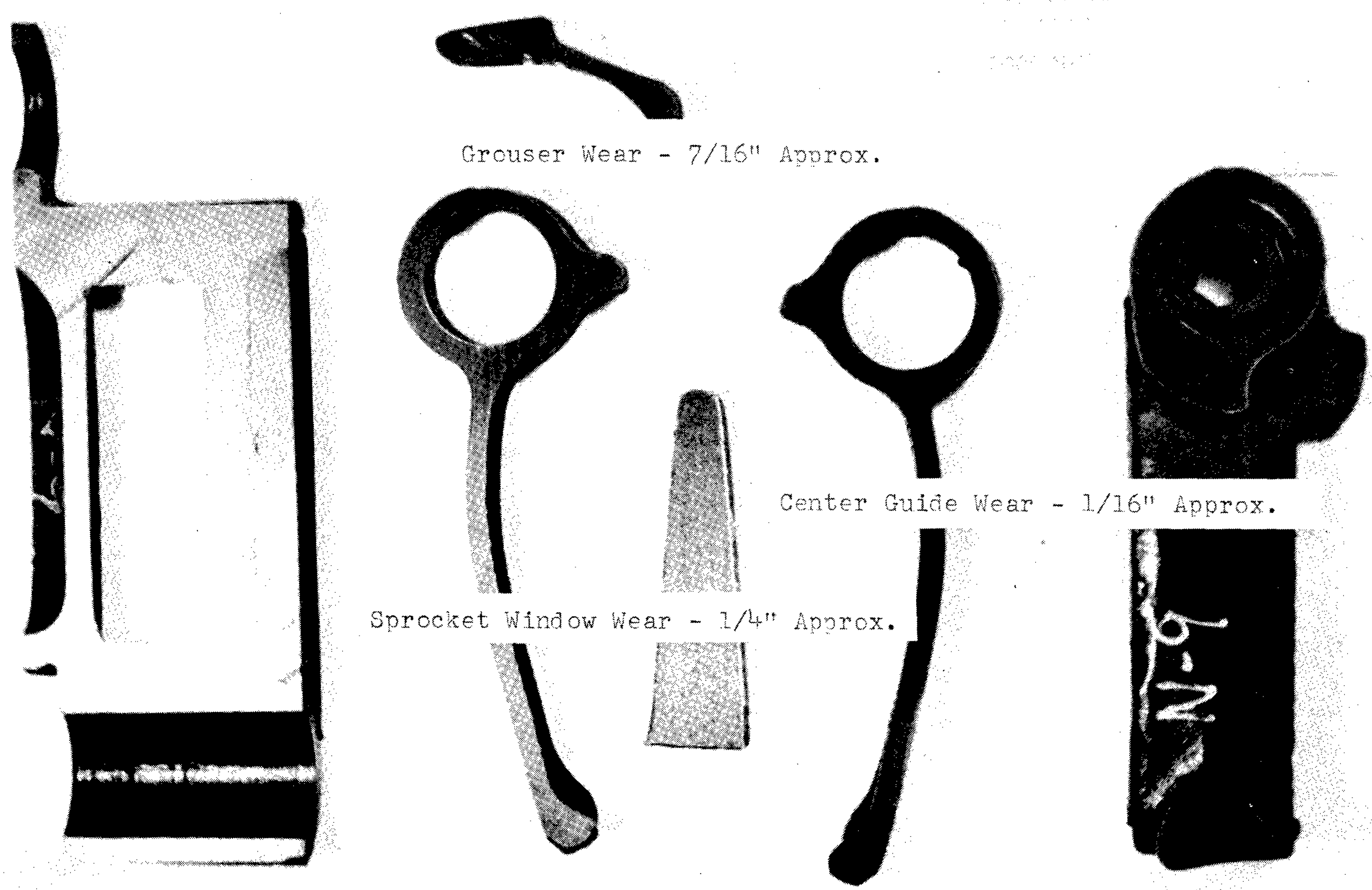


Figure 27

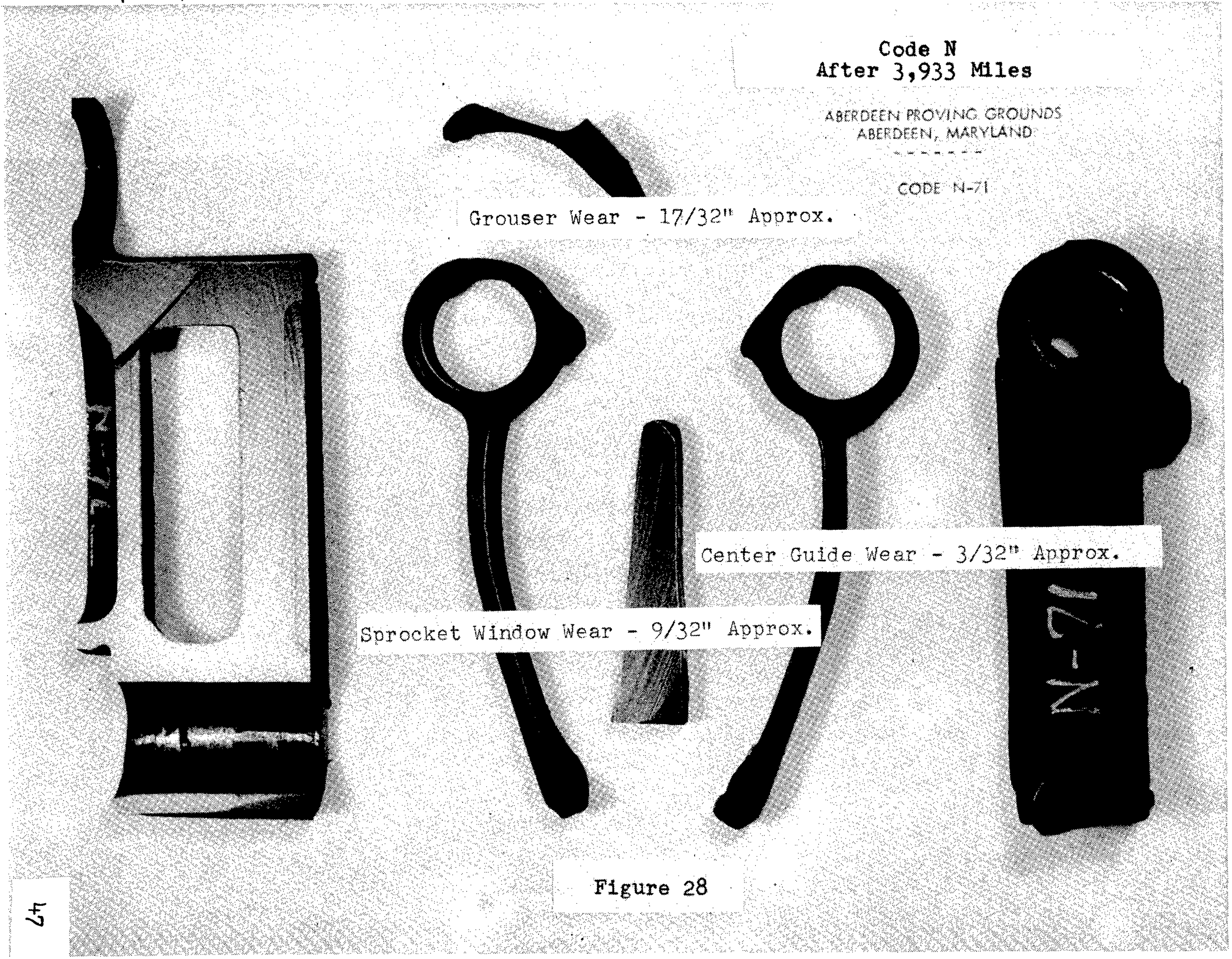

Code N
After 3,933 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE N-71
Grouser Wear - 17/32" Approx.
Center Guide Wear - 3/32" Approx.
Sprocket Window Wear - 9/32" Approx.
N-71
N-71

Figure 28

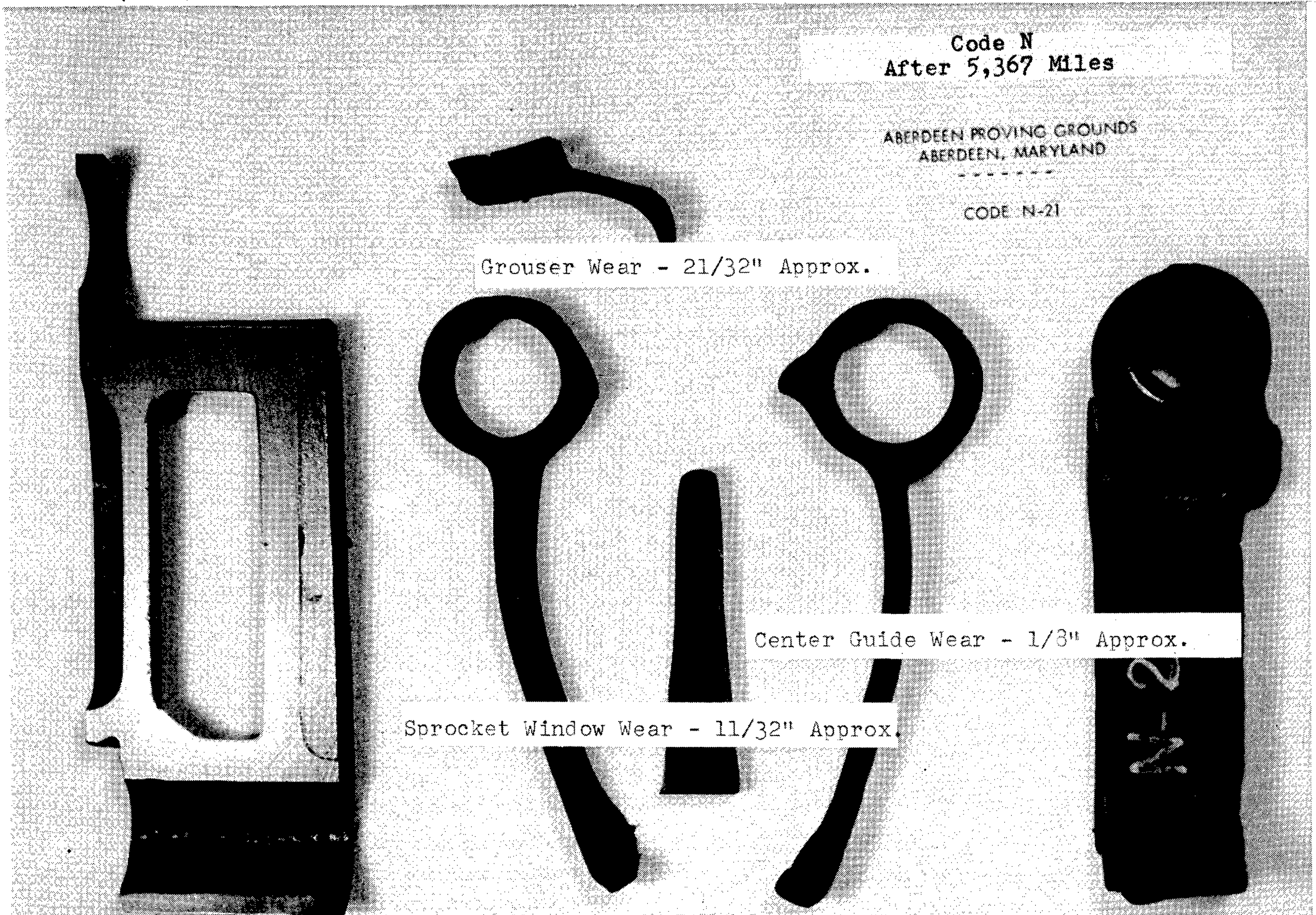

Code N
After 5,367 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE N-21
Grouser Wear - 21/32" Approx.
Center Guide Wear - 1/8" Approx.
Sprocket Window Wear - 11/32" Approx.
N-2

Figure 29

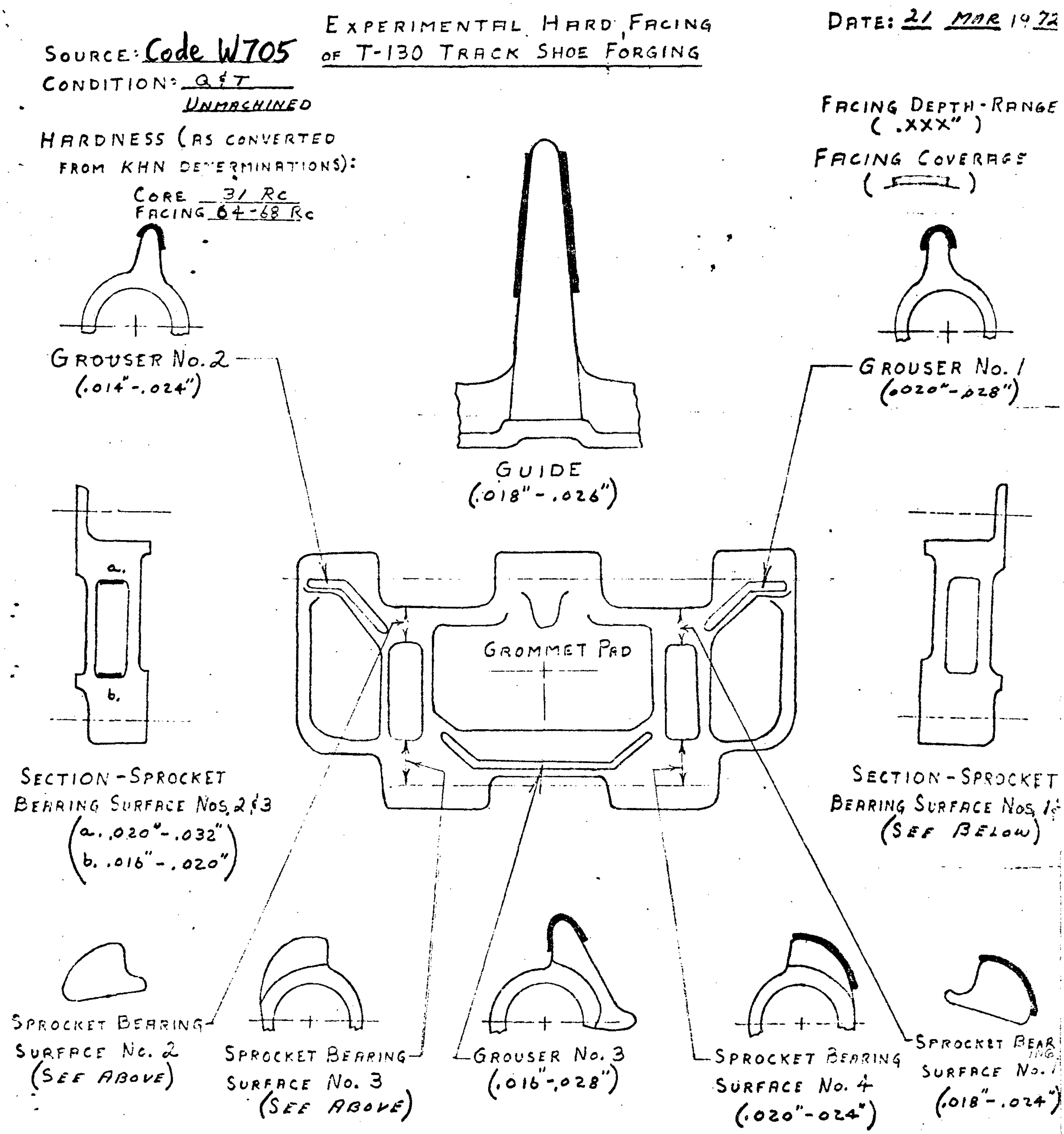


Figure 30

SECTIONED BEFORE MACHINING

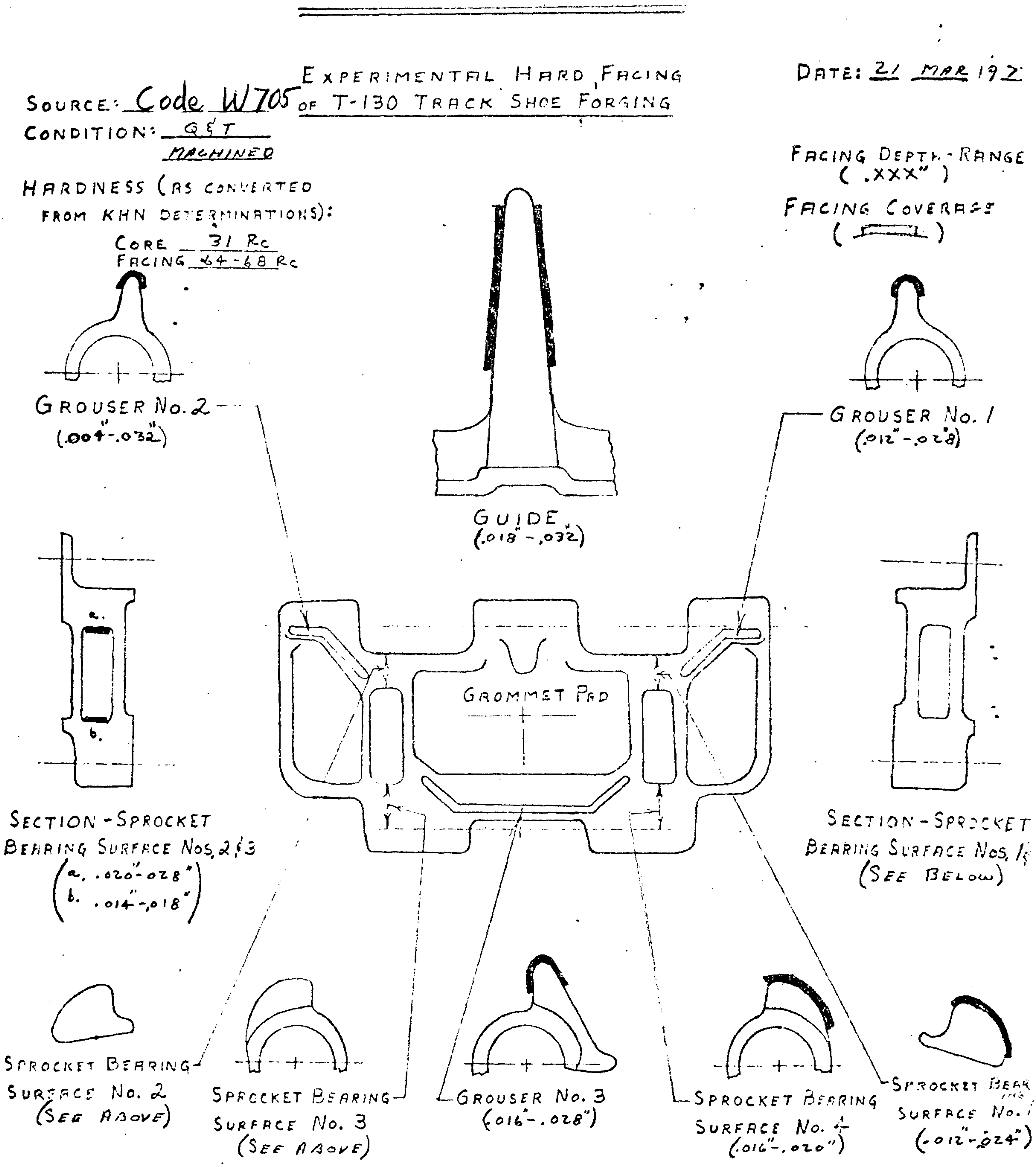


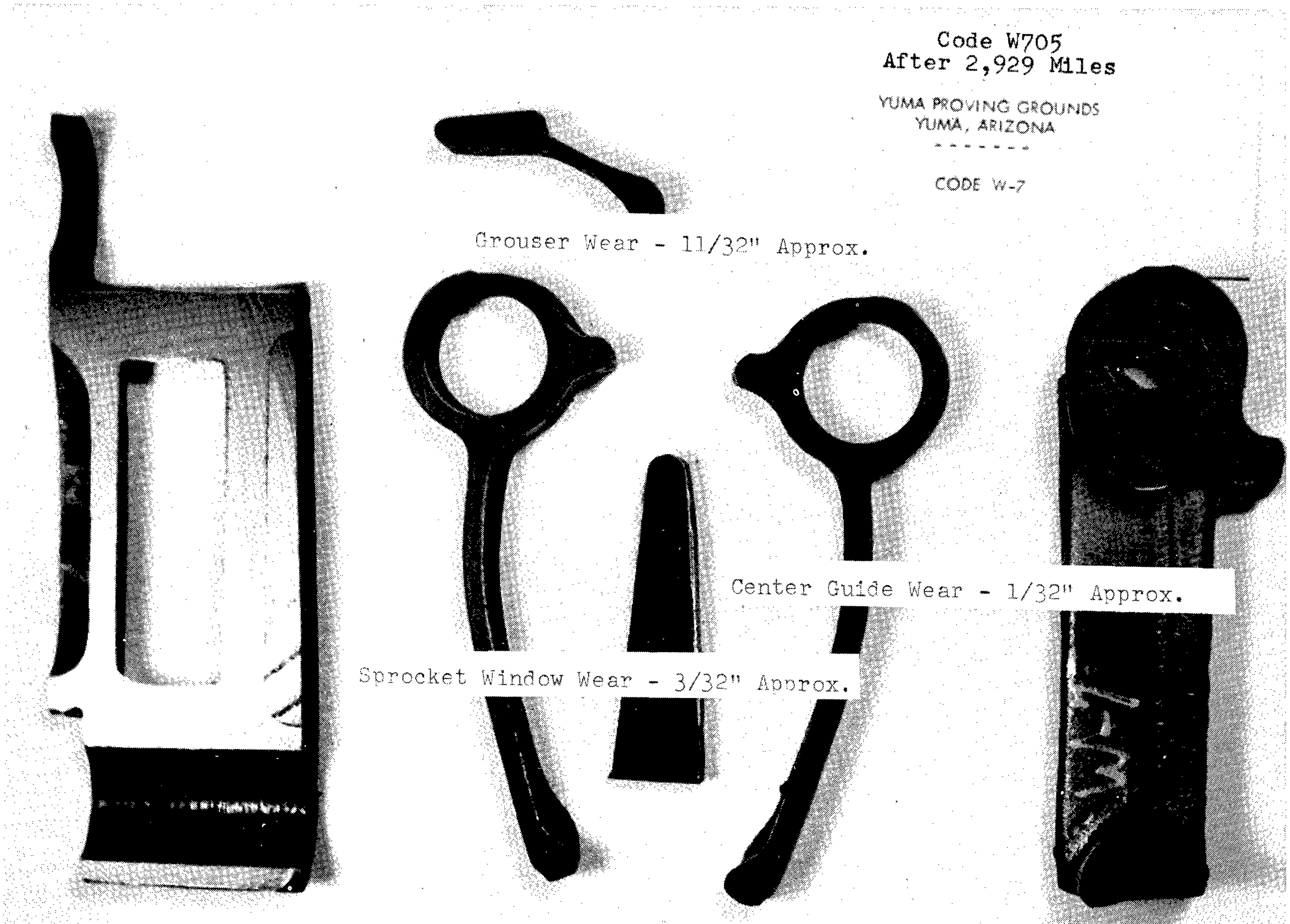
Figure 31

SECTIONED AFTER MACHINING

Code W705

Coating Thickness .020" Average

Figure 32 Before Field Test



Code W705
After 2,929 Miles
YUMA PROVING GROUNDS
YUMA, ARIZONA
CODE W-7
Grouser Wear - 11/32" Approx.
Center Guide Wear - 1/32" Approx.
Sprocket Window Wear - 3/32" Approx.

Figure 33

Code W705
After 3,563 Miles

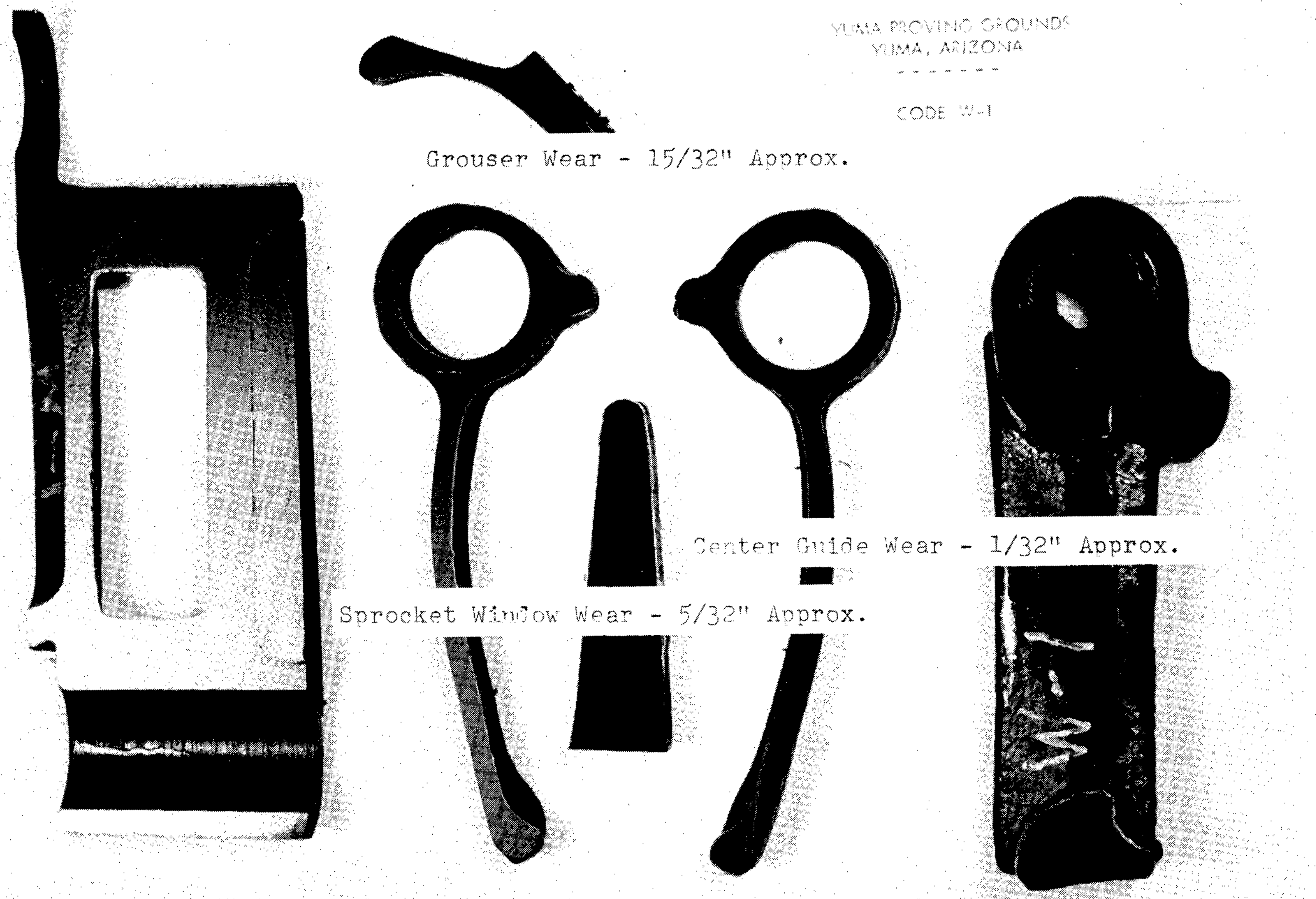


Figure 34

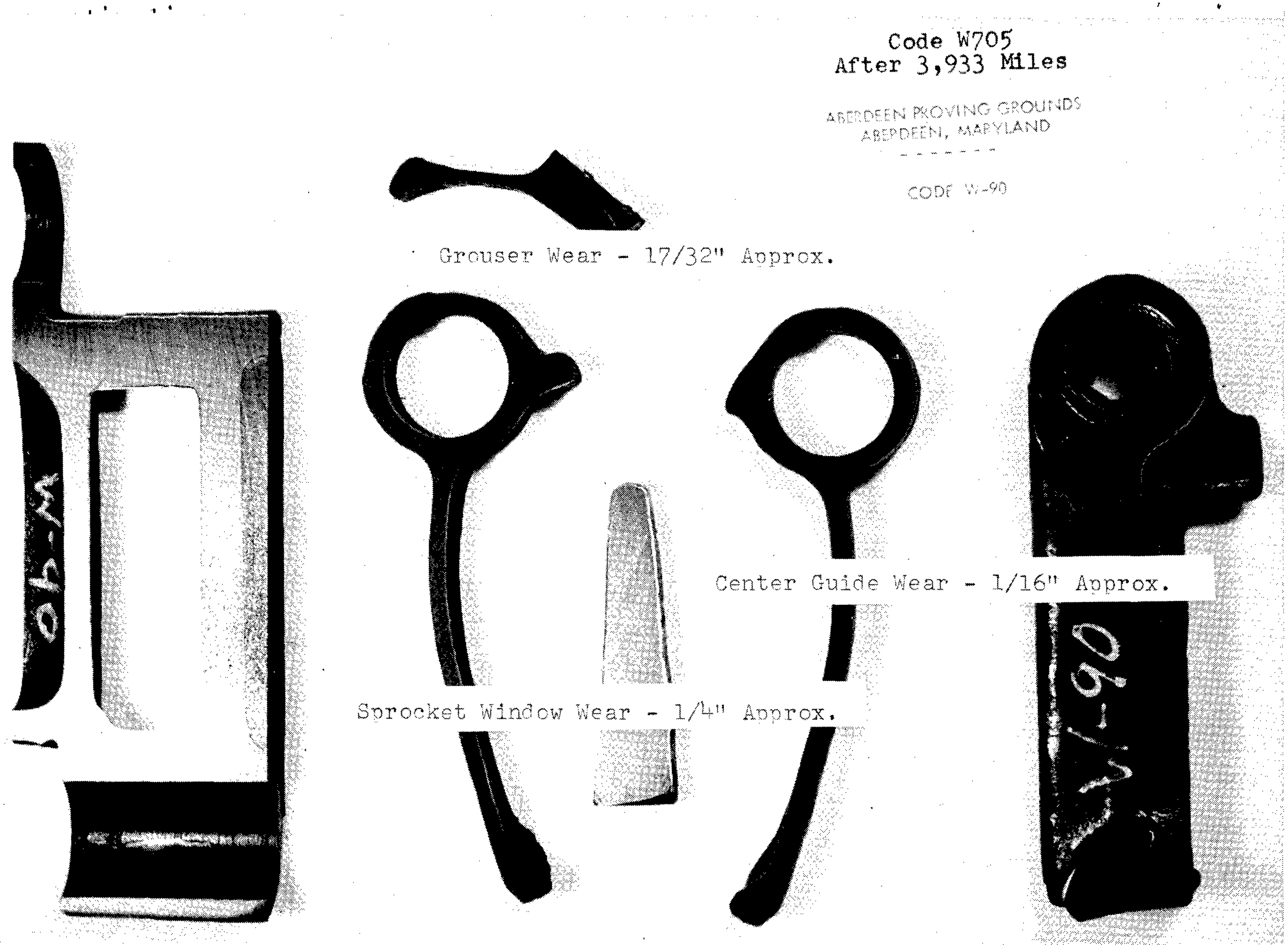

Code W705
After 3,933 Miles
ABERDEEN PROVING GROUNDS
ABERDEEN, MARYLAND
CODE W-90
Grouser Wear - 17/32" Approx.
Center Guide Wear - 1/16" Approx.
Sprocket Window Wear - 1/4" Approx.
W-90
W-90

Figure 35

Code W705
After 5,367 Miles

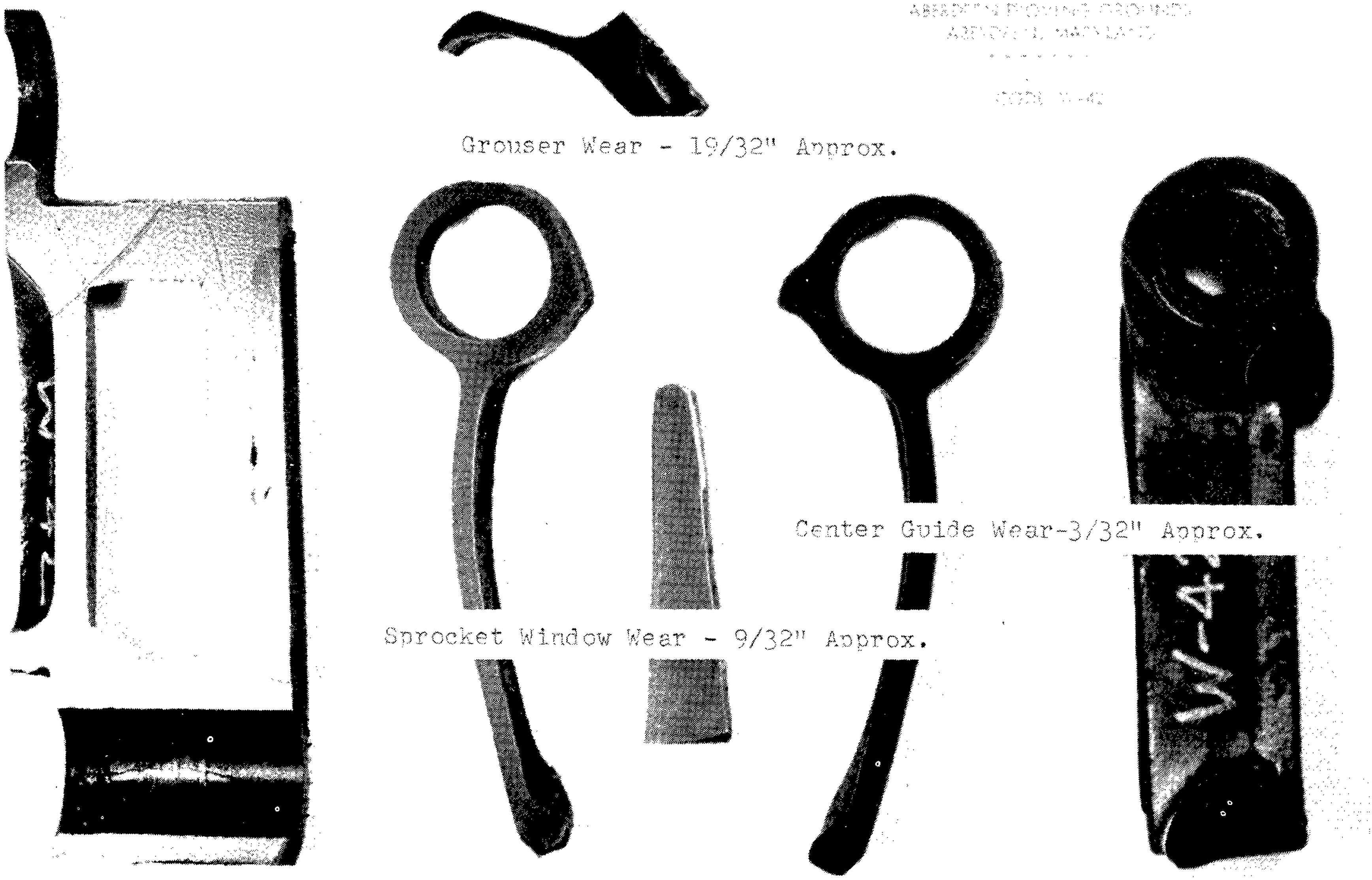


Figure 36

PART III - Continued:

4. QUALITY ASSURANCE PROVISIONS

If the hard surfacing T130 track shoes, Ordnance #11633919, is permitted in lieu of induction hardening, or as an alternative to induction hardening, the following additions to the Supplementary Quality Assurance Provision 11633919, Revision D, dated 8/21/69 should be considered.

It is suggested that Paragraph 3.1.1 on page 3 be changed to read "SECTIONAL SPECIMENS FOR FLAME OR INDUCTION HEAT TREAT EVALUATION (see Paragraph 6.1.1) OR FOR ALTERNATE HARD SURFACING APPLICATION EVALUATION (see Paragraph XXX)."

Characteristics 4, 5 and 6 on page 4 should also be changed to include the alternative hard surfaced material. The material should be .025 to .035 inches thick after fusing and shall contain metallic carbides of not less than 50% by volume in an iron or chrome-nickel-boron mixture.

Paragraph 6.1.1 should be modified to indicate that it applies only to flame or induction hardening methods. An additional paragraph should be added for the hard surfacing method if it is selected as an alternative. However, consideration must be given to the fact that .025 to .035 inches of additional material will be placed on top of the high wear areas when the hard surfacing or hard coats technique is used. If the basic machine forging 11633919 is to be used on an unaltered basis, provisions must be made to permit the inspectors to accept material with increased dimensions in these areas. As a result, the inspection method control sheets, pages 13, 14, and 15 of the SQAP 11633919 should also be changed to reflect the increased dimensions as a result of a hard coat or hard surface application.

It is also recommended that alternate section drawings for SQAP 11633919 be produced to detail the inspection of hard surface or hard coated track shoes. An inspection guide similar to figure 30 of this report is recommended.

5. RECOMMENDATIONS FOR PRODUCTION CONTROL

After our experience in the production of the pilot lot of some 900 hard coated or hard surfaced T130 track shoes, we recommend that the following points be included as a minimum in the material specifications and quality assurance provisions for hard surfacing of the T130 track shoe.

A) Material:

The hard coat material shall consist of a metallic carbide in an iron or chrome-nickel-iron matrix.

B) The metallic carbide shall consist of not less than 50% of the total volume consisting of matrix and metallic carbides.

C) It is recommended that the hard surfacing material be applied only to a shoe that has been cleaned and which is free from scale and grease. All track shoes should be degreased if necessary and blasted clean with steel shot.

D) The hard surfacing material shall be applied to a thickness of .025 to .035 inches after fusing. The hard surfacing material is to be applied to a shot blasted forging prior to normalizing, quenching, tempering, and machining. The hard surfacing or hard coating operation is to be conducted in a nitrogen free atmosphere.

E) The hardness of the iron or chrome-nickel-iron matrix shall have a minimum hardness reading of Rockwell C50 as converted by a Knoop or diamond pyramid hardness (DPH) test.

F) Since the proposed hard coat or hard surface method is applied on top of the basic machined forging 11633919 rather than a localized heat treatment of the machined forging, it is recommended that a coupon control sample be used in lieu of an entire track shoe for the micro-hardness test and a determination of particle size. However, it is recommended that the contractor be required to select samples for sectional cutting at the rate of one per 24 hour period. It should be noted that the proper positioning of the hard coat or hard surfacing material can be determined by exterior measurement of the material as it lies on the track shoe. However, induction or flame hardening requires sectional cutting of the forging for verification.

G. It is recommended that whatever material note is finally proposed as a revision to the drawing and whatever quality assurance provisions are selected, that they be submitted to the hard surfacing material manufacturers utilized in this investigation. Since these manufacturers would have to produce the end product, it is recommended that their comments and suggestions be solicited. It is also recommended that the comments and recommendations of the present group of prime contractors involving specification MIL-T-11891 be solicited before the final adoption of any specification or Quality Assurance Provision.

H. It should be emphasized that the other supplementary quality assurance provisions contained in SQAP 11633919 should not be deleted. For an example, the frequency of inspection of this track shoe should be as specified in the present revision of the SQAP. The clause detailing what to do if certain production control inspection tests are not passed should also be included. First article inspections should also be continued in line with SQAP 11633919. The inspection clause requiring 100% magnetic particle inspection after final heat treat must also be included to assure that no cracked forgings escape the inspection process.

6. COST EVALUATION AND ANALYSIS OF PRODUCTION CAPABILITY

The costs to hard-surface track shoes shown in Table 4 are based on actual quotations from the firms involved. These quotations were submitted in April and May of 1973. When we requested quotations from firms selected under Part II, we were advised by company Code W705 that they were no longer interested and did not wish to submit a

Induction Hardened	Code C601	Code N	Code I6A	Code W705	
$ .50	$ --	$ --	$ --	Declined to Furnish Estimate	Induction hardening
--	13.95	4.75	2.68		Hard surfacing
10.60	10.60	10.60	10.60		Other costs to produce a machined forging[1]
11.10	24.55	15.35	13.28		Machined track shoe 11633919 complete with either hard surfacing or induction hardening
2.09	2.09	2.09	2.09		Balance of metal parts[2]
13.19	26.64	17.44	15.37		Total metal
.69	.69	.69	.69		Balance of material including packaging
13.88	27.33	18.13	16.06		Total material
3.07	3.48	3.20	3.14		Labor, overhead, and general and administrative expenses to rubberize and assemble
$16.95	$30.81	$21.33	$19.20		Total cost of complete shoe assembly 11633928-6 assembled into eight shoe sections including preservative

Note [1] Includes cost of basic forging; freight to heat treater and machine shop; normalizing, quenching, tempering, and cleaning; straightening of heat distorted shoes; sectionalizing of shoes to measure depth of hardening and degree; Magnafluxing and grinding; machining; defective allowance for Magnaflux and machining operations; and freight to rubber factory.

Note [2] Balance of metal parts includes: Long and short bushings, track pin, two track pin nuts, pad plate, pad bolt, and pad nut, and an allowance for metal defective resulting from assembly and curing operations.

Table 4, Cost Comparison
Induction Hardening Vs. Hard Surfacing

quotation estimate for mass production. The quantity of track shoes ranging from 50,000 to 500,000 shoes per month had little influence on the cost estimates contained in Table 4. As long as the monthly delivery rate remained approximately 30,000 shoes (a range of 20 to 40 thousand shoes per month), all present production facilities were capable of handling that level of production.

However, equipment would be required on a one-time basis for a mass production hard surfacing operation. Estimates for this tooling run from a high of $300,000 to $500,000 by Code I6A for the equipment to produce at the rate of 60,000 shoes per month, to a low of $51,700 for Code C601. Company Code N indicated that they had some tooling and might be able to handle the required monthly production rate. An examination of the tooling or production equipment was not permitted.

The cost of start up tooling and equipment has not been included in Table 4, the cost estimation, since it is a one-time expenditure. In order to make a reasonable comparison it was assumed that induction hardening equipment and hard surfacing equipment were available, although in reality induction hardening equipment is available and to the best of our knowledge, hard surfacing equipment to handle track shoes in this volume does not exist with the possible exception of Code I6A. This firm has mass production equipment designed for use on agricultural implements that could be used for hard surfacing track shoes.

7. POSSIBILITIES FOR APPLICATION

Although the T130 track shoe (11633919) has been replaced by the T130E1 track shoe (11646782), this change has little impact on the cost structure shown in Table 4. The basic forging required to produce the T130 track shoe was more expensive than the T130E1 track shoe because the T130 track shoe required 4140H steel. The T130E1 track shoe permits the use of 1345H steel which has substantially reduced the cost of forging, basic heat treating, and machining operations as well as the defective rate for these operations. At this time we see no reason why the T130E1 track shoe, weighing one to two pounds more than the T130 track shoe, could not be hard surfaced in lieu of induction hardening.

Should at any time the cost picture change, making hard surfacing of the T130E1 track shoe economically feasible, it is recommended that hard surfacing be considered in lieu of induction hardening for the T91E3, T132E1, T136, and the T138 track shoes as well as the center guides and end connectors that may be induction hardened on the T84E1, T97E2, T107, and T142 track shoes.

8. LESSONS LEARNED

If we were to repeat this investigation or make a similar investigation, we would make the following changes based on what we learned.

A. It was originally requested that the 6,000 mile vehicle test include the measurement of the grouser wear every 500 miles. When the length of the test was reduced to 4,000 miles, the grouser measurement was increased to every 2,000 miles with only a visual inspection every 500 miles.

As a result, we were unable to determine which hard surface coating had the fastest rate of wear since by the time the track shoes were measured at 2,000 miles, all hard surfaces had been penetrated. If we were going to conduct the field test again, we would insist upon measurement of the hard surfaced shoes and the control shoes at 500 miles. Because of the expense and time consumed in making these calculations, it is recommended that a sample of each type of shoe under test be made. A statistical sampling of the various lots under test would greatly reduce the time required to take the measurements of the degree of wear.

B. At the time we started this investigation we suspected the bushing life would be the major cause of shoe failure. However, we were hesitant to introduce a new variable into the test. Superior bushing compounds and/or designs are available and are used in the T130E1 track shoe. If we were to repeat this test, we would recommend the use of superior bushing compounds and/or designs. At this time we see little advantage to the rebushing of the test shoes to continue field tests since the rate of wear can be projected. Although the hard surfacing of T130 track shoes is a feasible substitute for the induction hardening presently used on the T130 track shoes, the cost of hard surfacing the shoes is more than the cost of induction hardening track shoes. Although the laboratory wear tests suggested that a hard surface track shoe would far outlast an induction hardened track shoe, this did not prove to be the case during field testing. In fact, hard surface track shoes did not last as long as induction hardened track shoes when tested at Aberdeen and Yuma Proving Grounds. The reason for the rapid wear of the hard surfacing materials in actual field use in unknown. It is suspected that it might be a function of the impacting of the track shoe against the ground or against the wear surfaces of the drive sprockets and the road wheels might play a part in the rapid wear of the material. It is also possible that the base material holding the carbide particles was eroded away during actual operation.

The higher cost of the hard surfacing technique compared to the induction hardening technique might be significantly reduced if a mass production technique for the induction fusion of hard surfacing materials could be perfected. Company Code C601 was attempting to develop such a technique at the time of this investigation. The induction fusion of these materials would eliminate the expensive controlled atmosphere furnaces required by the present processes.

CONCLUSIONS

Although the hard surfacing of non-lubricated wear areas of track shoes such as the T130 is a feasible substitute for induction hardening, the material and labor costs of hard surfacing are considerably more. In the course of this investigation no significant advantages other than the possible reduction in the number of cracked shoes which might result from improper induction hardening were found.

A comparison of induction hardened surfaces to hard coated surfaces under actual field tests did not bear out the results of the laboratory abrasion tests. Although the hard coatings considered were all very much more resistent to abrasion than 4140A steel in the range of Rockwell C 52-54 during the laboratory weight loss tests, this was not the case during the actual vehicle tests at Yuma and Aberdeen Proving Grounds. Hard surfaced shoes lasted no longer than standard induction hardened shoes. As a result hard surfaced shoes did not prove to be less expensive on a cost per mile basis.

APPENDIX

DEPARTMENT OF THE ARMY
ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

MrAdler/is/870-?330

STEAP-MT-U

2 November 1972

SUBJECT: Final Letter Report of Product Improvement Test of T130 Fuse Coated Steel Track Shoes, TECOM Project No. 1-VC-017-130-012, Report No. APG-MT-4184

Commander
US Army Tank-Automotive Command
ATTN: AMSTA-RKMM
Warren, Michigan 48090

1. REFERENCE:

Letter, AMSTE-BB, 29 Feb 72, subject: Customer Test Directive: Product Improvement Test of T130 Fuse Coated Steel Track Shoes, TECOM Project No. 1-VC-017-130-012, w/inclosure - AMSTA-RPT letter.

2. BACKGROUND:

a. The present T130 track assembly of composition 4140 steel has a vehicular track life of approximately 4000 miles. Fuse coated shoes have shown an increase in durability as a result of previous tests. Four types of fuse coating (slurry, spray, tape, and sprinkle processes) were subject to endurance testing. The fuse coating on the test shoes had been applied to the grousers, sprocket windows and centerguides.

b. Four sections of 12 shoes of each type, separated by sections of 3 standard shoes were installed on each side of Armored Personnel Carrier, M113A1, USA Reg. No. 12A96169. Vehicle gross weight was 34,000 pounds.

c. A 6000-mile endurance test was conducted from 22 May 72 to 10 Oct 72 at this installation by Materiel Testing Directorate. The purpose of the test was to determine the durability of the 4 types of fuse coated track shoes.

3. OBJECTIVE:

To evaluate the durability of the 4 types of T130 fuse coated (4140 steel) track shoes as compared with the production steel track shoes.

STEAP-MT-U
SUBJECT: Final Letter Report of Product Improvement Test of T130 Fuse Coated Steel Track Shoes, TECOM Project No. 1-VC-017-130-012, Report No. APG-MT-4184

4. SUMMARY OF RESULTS:

a. A 6000-mile vehicular test consisting of the following was conducted:

Hard Surface and Gravel	600 miles
Gravel and Dirt Road	1500 miles
Level Cross-Country	1950 miles
Hilly Cross-Country	1950 miles

b. The track shoes were visually inspected for cracks every 1000 miles and 1 standard shoe and 1 each of the 4 types of fuse coated shoes in the left track were measured for wear.

c. Of the shoes selected for wear measurement, only the standard shoe and the shoe with the tape method of fuse coating completed the 6000-mile test. Of the 96 test shoes originally installed (24 of each type), only 9 completed the full mileage; 2 slurry process (I), 1 spray process (W), 3 sprinkle process (N), and 3 tape process (C). All track shoe failures were due to bushing failures.

d. The only cracks noted occurred with 1 tape type after 3000 miles, 1 slurry type after 4000 miles and 2 standard shoes after 4000 miles. The cracks were 1 to 1 and 1/2 inches in length running from inside and across the grouser, to the face of the grouser. The shoes continued in operation until bushing failure occurred.

e. Wear measurements were made periodically on the grousers, centerguides and sprocket engagement windows. The curves plotted from these data (Incl 1 thru 4) show trends only due to the limited sampling and the disparity in data. The measured wear of the grouser on the test shoes was within 1/10 of an inch of the standard shoe after 3000 miles, however, above this mileage divergence is noted.

f. The loss of the test shoes due to bushing failure precludes comparisons over the full 6000 miles of test; however, the wear rates of the fuse coated shoes up to 5000 miles indicate a close grouping of the standard shoes and the tape, spray and slurry methods of fuse coatings, with a preference of the tape method which had the lowest wear rate of all on the inboard corner of the front grouser.

5. CONCLUSIONS:

None.

STEAP-MT-U

SUBJECT: Final Letter Report of Product Improvement Test of T130 Fuse Coated Steel Track Shoes, TECOM Project No. 1-VC-017-130-012, Report No. APG-MT-4184

6. RECOMMENDATIONS:

None.

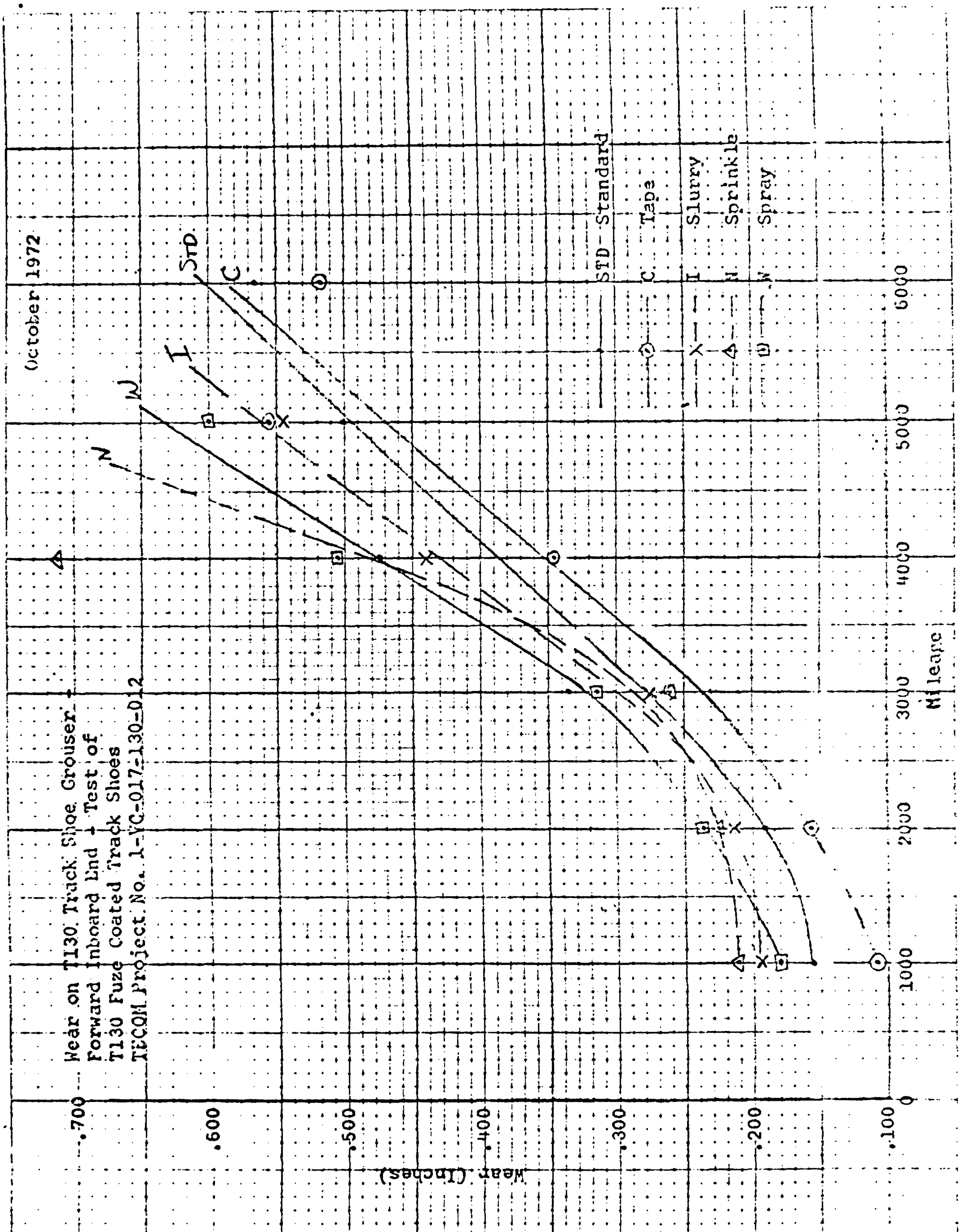
FOR THE COMMANDER:

(Signed)

4 Incls
as

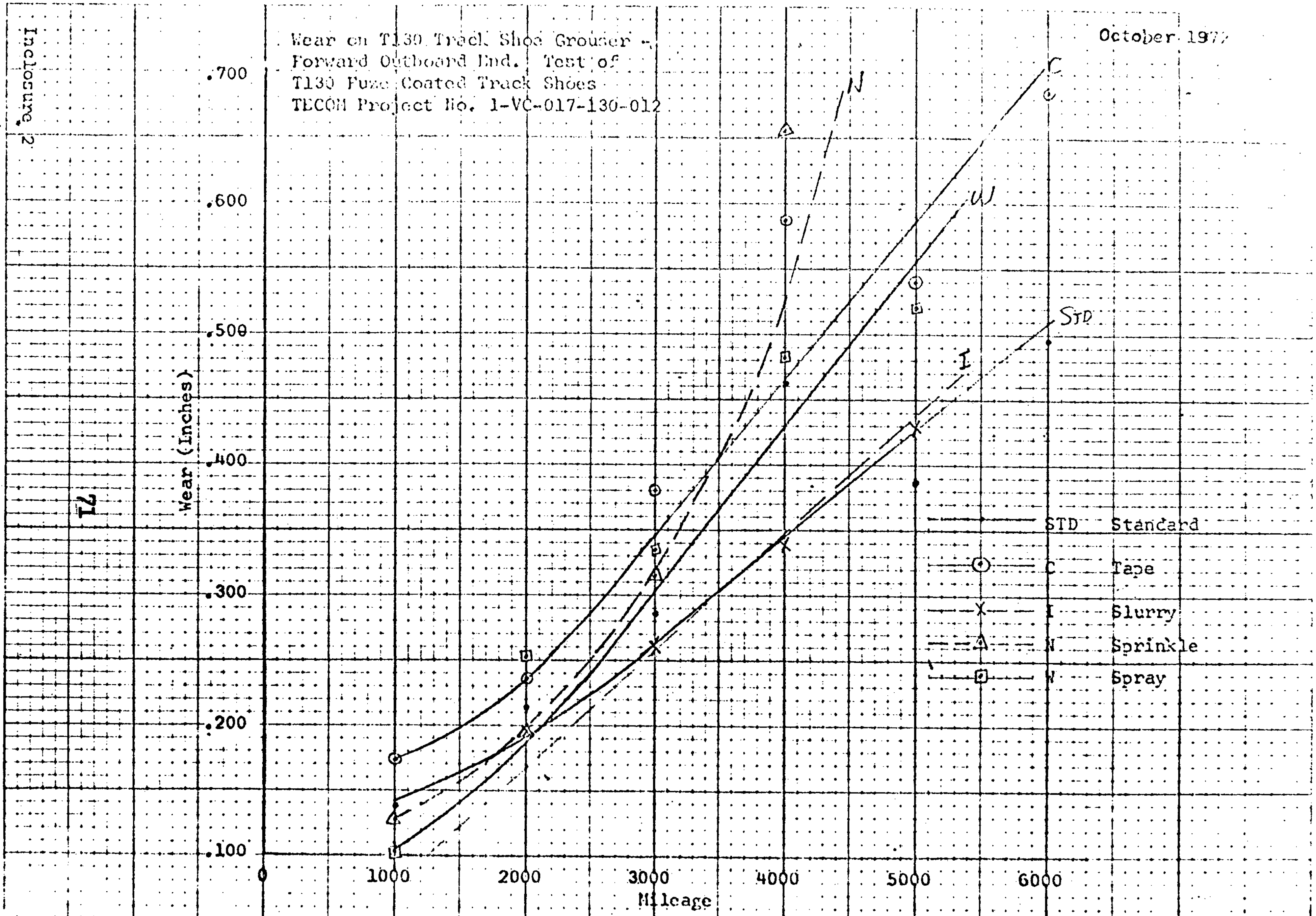
R. P. WITT
Associate Director
Materiel Testing Directorate

CF:
Cmdr, TECOM, ATTN: AMSTE-BB


Wear on T130 Track Shoe Grouser -
Forward Inboard End - Test of
T130 Fuze Coated Track Shoes
TECOM Project No. 1-VC-017-130-012
October 1972
STD Standard
C Tape
I Slurry
N Sprinkle
W Spray
STD
C
I
W
N
Mileage
0
1000
2000
3000
4000
5000
6000
Wear (Inches)
.100
.200
.300
.400
.500
.600
.700

Inclosure I

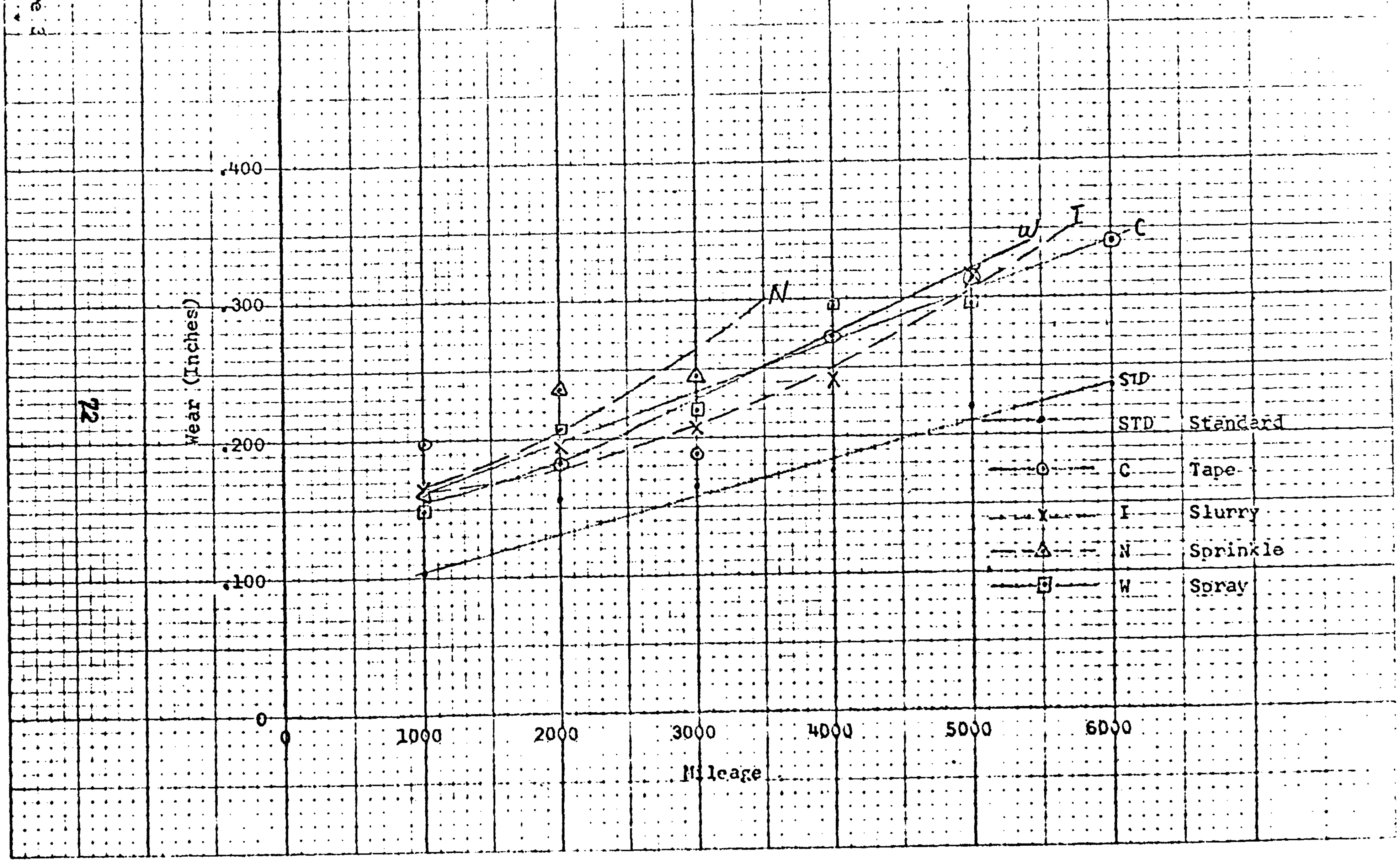
October 197?

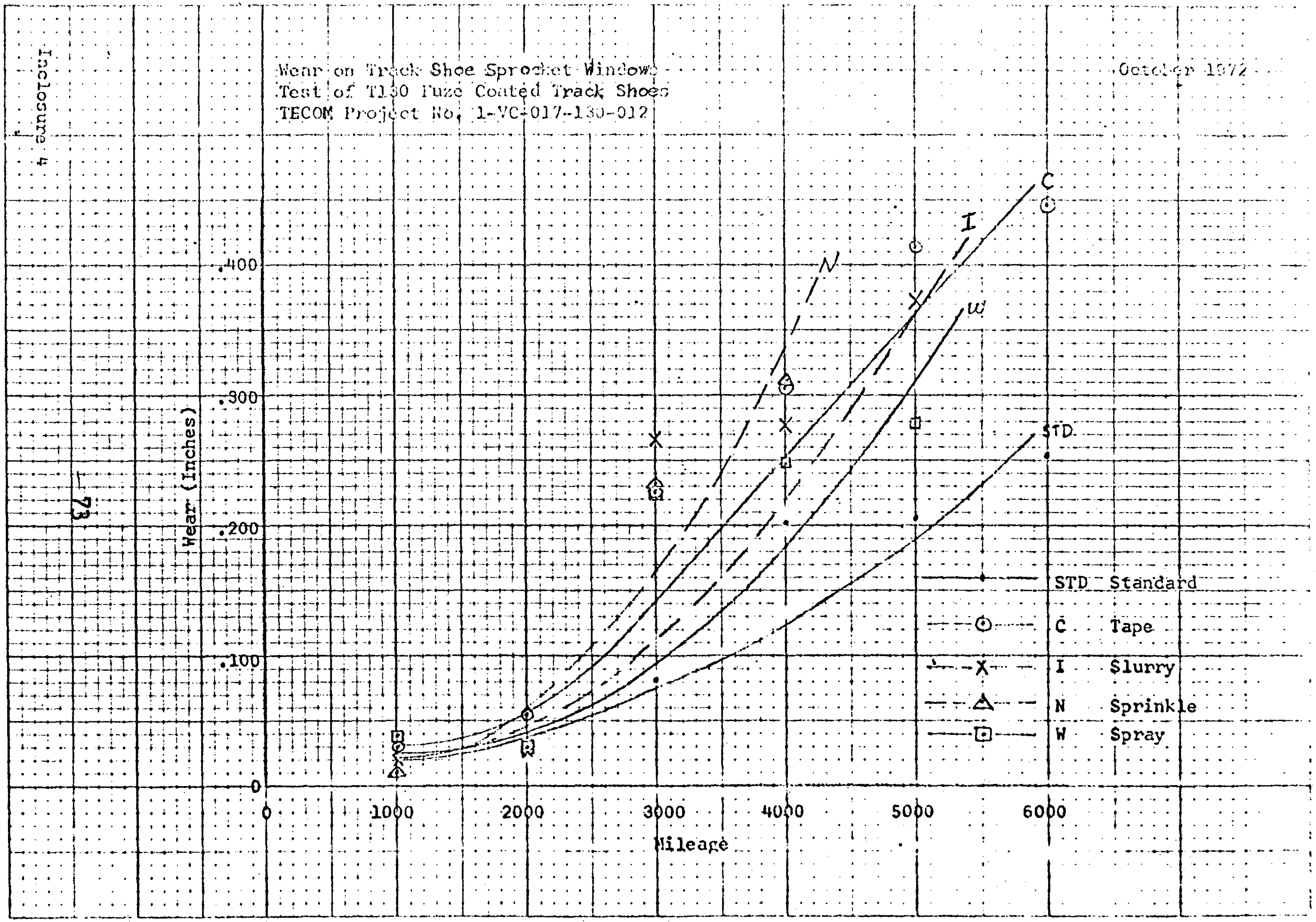


Inclosure 2

October 1972

Wear on Center Guide
Test of T130 Fuze Coated Track Shoes
TECOM Project No. 1-VC-017-130-012




Wear on Track Shoe Sprocket Windows
Test of T130 Fuze Coated Track Shoes
TECOM Project No. 1-VC-017-130-012
October 1972
Wear (Inches)
.400
.300
.200
.100
0
0
1000
2000
3000
4000
5000
6000
Mileage
C
I
N
W
STD
STD Standard
C Tape
I Slurry
N Sprinkle
W Spray

Inclosure 4

FOR INFORMATION ONLY
ACTION BY HIGHER AUTHORITY PENDING

AD ______

RDTE PROJECT NO. FSN ______

TECOM PROJECT NO. 1-VC-017-130-013

TEST SPONSOR USATAC

TEST AGENCY PROJECT NO. ______

TEST SPONSOR PROJECT NO. ______

USACDC AC NO. ______

YPG REPORT 0145

PRODUCT IMPROVEMENT TEST OF T130 FUSE-COATED TRACK SHOES FOR M113A1 ARMORED PERSONNEL CARRIER

FIRST AND FINAL LETTER REPORT

BY

RICHARD JORDAN, E2
SCIENTIFIC AND ENGINEERING
JANUARY 1973

~~Distribution limited to U.S. Government agencies only; test and evaluation; January 1973. Other requests for this document must be referred to Commander, U.S. Army Tank-Automotive Command, ATTN: AMSTA-RKM, J. W. Schuster, Warren, Michigan 48091.~~

Limitation removed Emma Lilley AMSTARKM 8 Jan 75

YUMA PROVING GROUND

YUMA, ARIZONA

Destroy this report when no longer needed. Do not return it to the originator.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purpose of advertisement.

DEPARTMENT OF THE ARMY
Yuma Proving Ground
Yuma, Arizona 85364

RJordon/mz/899-2829

STEYP-MTM

SUBJECT: First and Final Letter Report on Product Improvement Test of T130 Fuse-Coated Track Shoes for M113A1 Armored Personnel Carrier, TECOM Project No. 1-VC-017-130-013

Commander
U. S. Army Tank-Automotive Command
ATTN: AMSTA-RPT
Warren, Michigan 48090

Dates of Test: 3 May 1972 through 26 October 1972

1. REFERENCES

a. Customer Test Directive, Product Improvement Test of T130 Fuse-Coated Track Shoes, TECOM Project No. 1-VC-017-130-013, AMSTE-BB, 16 March 1972.

b. Third and Final Letter Report on Product Improvement Test of T130 Fuse-Coated Tuftrided Track Shoes, TECOM Project No. 1-4-7339-75, STEYP-TAU, 9 June 1969.

2. BACKGROUND

During previous tests, standard production T130 track shoes have evidenced cracking in the induction hardened areas of the shoes. Fuse-coated shoes have shown a marked increased in durability, wear life and freedom of cracks. This test compared the durability of various fuse-coated track shoes processed by four manufacturers with the present standard production track shoes.

The T130 Fuse-Coated Track Shoes were installed on two M113A1 armored personnel carriers undergoing comparison testing at Yuma Proving Ground under TECOM Projects No. 1-VC-010-113-029 and 030, Contract No. DAAE07-69-C-2600.

Initially a 6,000-mile test with measurement of grouser wear every 500 miles was requested but this proposal was later modified to a 4,000-mile test, measurement of grouser wear every 2,000 miles, and a visual inspection for cracks every 500 miles.

3. OBJECTIVE

To evaluate the durability of T130 fuse-coated track shoes (4140 steel) processed by four different methods as compared with production 4140 steel track shoes.

4. SUMMARY OF METHODS AND RESULTS

a. Receiving Inspection

This inspection was completed upon arrival of the T130 fuse-coated track shoes to determine if any damage had resulted from shipment and if proper shipping procedures had been utilized. No evidence of damage due to shipping was noted. Proper shipping procedures had been utilized.

b. Initial Technical Inspection

Pretest measurement data were taken on the track shoes to enable a wear rate analysis. In addition to the weight of each shoe, measurements of sprocket openings (inner and outer), grouser height relative to pad base (inner, outer, and leading edges), and overall grouser height (inner, outer, and leading edges) were taken. Measurements were also made on 16 standard production track shoes for the purpose of a comparison standard. All the test track shoes were stamped with a code letter and number for identification and to aid in wear analysis. The code letters, C, I, N, W, S are abbreviations for the processing method. They are as follows:

C - Tape process
I - Slurry process
N - Sprinkle process
W - Spray process
S - Standard comparison track

Results of this inspection and sketches of where measurements were taken are contained in Inclosure 1.

A total of 64 fuse-coated track shoes and 16 standard comparison track shoes were installed on the vehicle. Thirty-two fuse-coated and 32 standard track shoes were positioned on each side of the vehicle in the following sequence:

(1) 8 fuse-coated track shoes*
(2) 8 standard comparison track shoes
(3) 8 fuse-coated track shoes*

(4) 8 standard track shoes
(5) 8 fuse-coated track shoes*
(6) 8 standard track shoes
(7) 8 fuse-coated track shoes*
(8) 8 standard track shoes (7 in left track)

*Composed of two shoes from each of the four processing methods. After assembly all track pins were torqued as specified in the vehicle technical manual.

c. Endurance Testing

Testing was conducted in accordance with reference 1a. The track shoes completed a total of 4096 test miles (2047 miles accumulated on vehicle USA Reg No. 12A07272 and 2049 miles accumulated on vehicle USA Reg No. 12A10672). In an effort to normalize variables in vehicle operation, track shoes throughout the test were kept in the same relative positions on both vehicles. Worn or damaged shoes were replaced with track shoes which had been treated by the same fuse coating process. A detailed listing of events occurring during endurance test mileage is contained in Inclosure 2. Incidents noted during the endurance phase of operation are listed in Table 1.

TABLE 1. Endurance Phase Results of Fuse-Coated Track Shoes

Incident Description	Number of Shoes Involved in Incident	Accumulated Test Miles	Item No. Incl 2
1. Rubber bushing failure	2	2047	2.1.1
2. Rubber bushing failure	1	2608	2.1.2
3. Rubber bushing failure	5	2794	2.1.3
4. Rubber bushing failure	6	2929	2.1.3
5. Rubber bushing failure	4	3055	2.1.3
6. Rubber bushing failure	9	3276	2.1.3
7. Rubber bushing failure	2	3463	2.1.3
8. Rubber bushing failure	10	3578	2.1.3
9. Rubber bushing failure	9	3902	2.1.3
10. Rubber bushing failure	5	4096	2.1.3
11. Bent outer wing (road hazard)	2	1539	3.1
12. Bent outer wing (road hazard)	1	2794	3.2

All shortcomings incurred during the endurance phase of the test were directly attributable to bushing failures. No cracked track shoes were noted.

d. Final Technical Inspection

This inspection was conducted at 4096 test miles to determine the final test condition of the fuse-coated track shoes and to record post-test measurements.

Results of this inspection are contained in Inclosure 1.

5. DISCUSSION

During previous testing of T130 fuse-coated track shoes conducted at Yuma Proving Ground (TECOM Project No. 1-4-7330-75) 78 out of 127 fuse-coated track shoes (approximately 62%) failed during 6098 test miles due to bushing failure and one shoe was replaced due to cracking. During the current test 53 out of 64 fuse-coated track shoes (approximately 83%) failed due to bushing failure. No cracked shoes were noted.

In two separate incidents three fuse-coated track shoes were bent in the area of the outer wing. The damage was attributable to road hazards (rocks and boulders) and occurred at 1539 and 2794 test miles.

6. CONCLUSIONS

a. There is negigible difference in wear between the four fuse coating processes.

b. Standard T130 track shoes showed approximately 45 percent less grouser wear than the fuse-coated track shoes.

c. Durability of the T130 fuse-coated track shoe bushing is unsatisfactory.

STEYP-MTM
SUBJECT: First and Final Letter Report on Product Improvement Test of T130 Fuse-Coated Track Shoes for M113A1 Armored Personnel Carrier, TECOM Project No. 1-VC-017-130-013

7. RECOMMENDATION

More effort be expended on improving track shoe bushing life since a majority of track shoe replacements are due to failed bushings.

FOR THE COMMANDER:

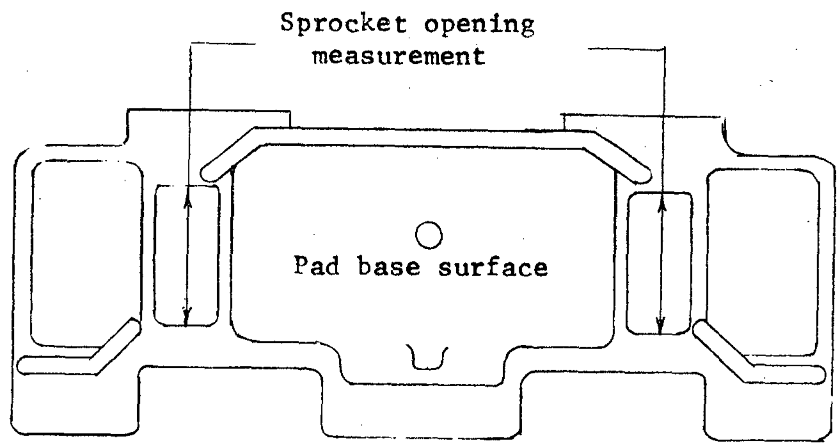
Ramon Heik
for GEORGE A. CUSTER
Col, Inf
Director of Materiel Test

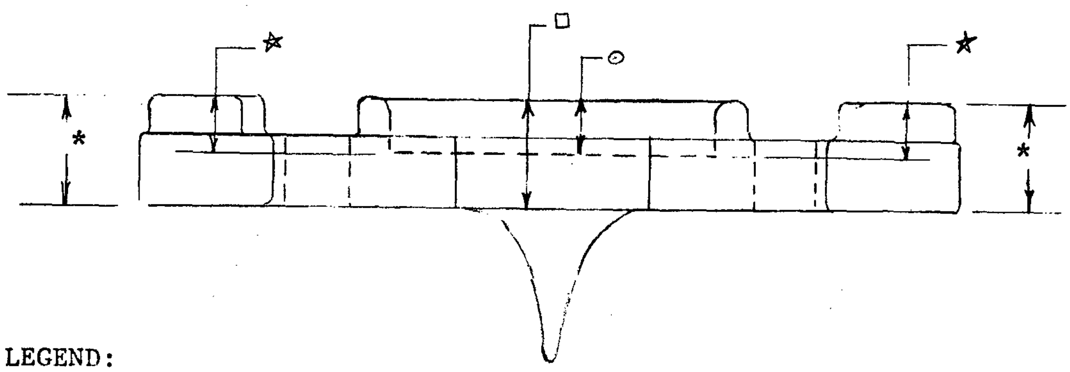
5 Incl
1. Initial, Intermediate and Final Inspections
2. Deficiencies and Shortcomings
3. Wear Rate Analysis
4. Distribution List

INITIAL, INTERMEDIATE, AND FINAL INSPECTIONS

Table No.	Inspection	At Test Miles
1	Initial	0
2	Intermediate	2047
3	Final	4096, and/or miles at time of shoe failure

The accompanying sketches of a track shoe locate where all shoe measurements were taken. These measurements should be read as follows:





LEGEND:
* Overall grouser height (inner or outer)
□ Overall grouser height (leading)
☆ Grouser height relative to pad base (left or right)
⊙ Grouser height relative to pad base (leading)

Incl 1
Page 1 of 7

TABLE 1. Track Shoe Measurements at Initial Inspection

Shoe No.	Grouser Height Relative to Pad Base			Sprocket Opening		Overall Grouser Height			Track Shoe Wt (lb)
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading	
C 1	1 12/32	1 12/32	1 14/32	3	2 31/32	2 11/32	2 11/32	2 12/32	15.61
2	1 13/32	1 13/32	1 13/32	2 31/32	3	2 10/32	2 10/32	2 12/32	15.13
3	1 12/32	1 12/32	1 13/32	2 31/32	2 31/32	2 11/32	2 10/32	2 10/32	15.46
4	1 13/32	1 11/32	1 13/32	2 30/32	2 31/32	2 11/32	2 10/32	2 11/32	15.98
5	1 12/32	1 13/32	1 14/32	2 31/32	2 31/32	2 11/32	2 10/32	2 10/32	15.35
6	1 11/32	1 11/32	1 13/32	2 30/32	2 31/32	2 11/32	2 11/32	2 10/32	15.33
7	1 14/32	1 12/32	1 13/32	2 31/32	2 31/32	2 12/32	2 10/32	2 10/32	15.73
8	1 13/32	1 11/32	1 13/32	2 31/32	3	2 11/32	2 10/32	2 10/32	15.66
9	1 11/32	1 13/32	1 14/32	3	3	2 11/32	2 11/32	2 10/32	15.22
10	1 12/32	1 11/32	1 13/32	2 31/32	2 31/32	2 10/32	2 11/32	2 11/32	15.42
11	1 11/32	1 12/32	1 14/32	2 31/32	2 31/32	2 11/32	2 11/32	2 12/32	15.36
12	1 12/32	1 12/32	1 14/32	3	2 31/32	2 10/32	2 11/32	2 10/32	15.86
13	1 13/32	1 13/32	1 14/32	2 31/32	2 31/32	2 11/32	2 11/32	2 12/32	15.93
14	1 12/32	1 12/32	1 13/32	2 31/32	2 31/32	2 10/32	2 11/32	2 10/32	15.33
15	1 12/32	1 12/32	1 13/32	3	2 31/32	2 9/32	2 10/32	2 10/32	15.00
C16	1 13/32	1 12/32	1 13/32	2 31/32	2 31/32	2 10/32	2 10/32	2 10/32	15.11
I 1	1 13/32	1 13/32	1 14/32	3	2 31/32	2 11/32	2 11/32	2 12/32	15.30
2	1 13/32	1 13/32	1 14/32	3	2 30/32	2 11/32	2 12/32	2 12/32	15.85
3	1 12/32	1 14/32	1 14/32	3	3	2 10/32	2 12/32	2 11/32	15.91
4	1 13/32	1 13/32	1 14/32	3	3	2 11/32	2 11/32	2 11/32	15.69
5	1 14/32	1 14/32	1 14/32	3	2 31/32	2 11/32	2 11/32	2 12/32	15.81
6	1 13/32	1 13/32	1 14/32	3	2 31/32	2 11/32	2 12/32	2 11/32	16.25
7	1 13/32	1 13/32	1 14/32	3	2 31/32	2 10/32	2 11/32	2 11/32	15.39
8	1 13/32	1 13/32	1 14/32	3	3	2 10/32	2 12/32	2 12/32	15.82
9	1 13/32	1 13/32	1 14/32	3	3	2 12/32	2 11/32	2 11/32	15.81
10	1 14/32	1 15/32	1 14/32	2 31/32	2 31/32	2 11/32	2 12/32	2 11/32	15.45
11	1 13/32	1 13/32	1 14/32	2 30/32	2 31/32	2 11/32	2 11/32	2 11/32	15.99
12	1 12/32	1 22/32	1 14/32	2 31/32	3 1/32	2 10/32	2 10/32	2 10/32	15.46
13	1 16/32	1 14/32	1 15/32	3	3	2 13/32	2 11/32	2 11/32	15.76
14	1 14/32	1 13/32	1 14/32	2 31/32	3	2 10/32	2 12/32	2 10/32	15.21
15	1 13/32	1 12/32	1 14/32	2 31/32	2 30/32	2 10/32	2 10/32	2 10/32	15.44
I16	1 13/32	1 14/32	1 14/32	2 30/32	2 31/32	2 14/32	2 12/32	2 12/32	15.42
N 1	1 13/32	1 12/32	1 14/32	3	3	2 11/32	2 11/32	2 13/32	16.35
2	1 12/32	1 13/32	1 14/32	3	3	2 10/32	2 12/32	2 13/32	15.85
3	1 13/32	1 13/32	1 14/32	3	3	2 11/32	2 10/32	2 11/32	15.94
4	1 12/32	1 12/32	1 14/32	2 30/32	3	2 9/32	2 11/32	2 12/32	15.84
5	1 13/32	1 12/32	1 14/32	3	3	2 12/32	2 12/32	2 12/32	16.05
6	1 12/32	1 12/32	1 14/32	3	3	2 10/32	2 10/32	2 12/32	15.65
7	1 12/32	1 13/32	1 14/32	3	3	2 10/32	2 13/32	2 11/32	15.85
8	1 12/32	1 12/32	1 14/32	3	2 31/32	2 12/32	2 10/32	2 12/32	16.03
9	1 12/32	1 13/32	1 14/32	2 31/32	3	2 11/32	2 11/32	2 11/32	15.62
10	1 13/32	1 13/32	1 14/32	3	3	2 12/32	2 12/32	2 13/32	16.13
11	1 12/32	1 12/32	1 14/32	3	3	2 11/32	2 11/32	2 10/32	16.11
12	1 12/32	1 12/32	1 13/32	2 31/32	3	2 10/32	2 11/32	2 12/32	15.47
13	1 12/32	1 12/32	1 13/32	2 31/32	2 31/32	2 12/32	2 10/32	2 13/32	16.36
14	1 13/32	1 13/32	1 12/32	2 31/32	2 31/32	2 10/32	2 11/32	2 11/32	15.80
15	1 12/32	1 13/32	1 13/32	2 31/32	2 31/32	2 11/32	2 11/32	2 12/32	16.18
N16	1 12/32	1 12/32	1 13/32	3	3	2 10/32	2 11/32	2 10/32	15.76
W 1	1 13/32	1 15/32	1 13/32	2 29/32	2 28/32	2 12/32	2 12/32	2 12/32	16.42
2	1 13/32	1 13/32	1 14/32	2 31/32	2 30/32	2 10/32	2 11/32	2 12/32	15.82
3	1 13/32	1 10/32	1 14/32	2 30/32	2 29/32	2 11/32	2 7/32	2 14/32	16.51
4	1 12/32	1 13/32	1 14/32	3	3	2 9/32	2 12/32	2 13/32	15.97
5	1 13/32	1 12/32	1 14/32	3	2 31/32	2 10/32	2 11/32	2 13/32	16.37
6	1 12/32	1 12/32	1 14/32	3	2 31/32	2 10/32	2 12/32	2 14/32	15.67
7	1 11/32	1 11/32	1 14/32	3	2 31/32	2 11/32	2 11/32	2 14/32	15.94
8	1 13/32	1 12/32	1 15/32	2 30/32	2 30/32	2 10/32	2 12/32	2 12/32	15.70
9	1 13/32	1 13/32	1 14/32	2 31/32	2 30/32	2 13/32	2 11/32	2 14/32	15.85
10	1 13/32	1 13/32	1 15/32	2 30/32	2 30/32	2 13/32	2 11/32	2 13/32	16.16
11	1 13/32	1 13/32	1 14/32	2 31/32	2 31/32	2 12/32	2 12/32	2 13/32	16.00
12	1 12/32	1 13/32	1 15/32	2 31/32	2 30/32	2 11/32	2 11/32	2 13/32	15.58
13	1 13/32	1 13/32	1 14/32	2 28/32	2 31/32	2 12/32	2 11/32	2 14/32	15.62
14	1 14/32	1 12/32	1 15/32	2 29/32	2 30/32	2 11/32	2 10/32	2 12/32	16.16
15	1 13/32	1 13/32	1 13/32	2 29/32	2 31/32	2 13/32	2 13/32	2 14/32	16.15
W16	1 13/32	1 12/32	1 15/32	2 31/32	2 31/32	2 13/32	2 12/32	2 14/32	15.76

TABLE 1. Track Shoe Measurements at Initial Inspection (Concluded)

Shoe No.	Grouser Height Relative to Pad Base: Inner	Grouser Height Relative to Pad Base: Outer	Grouser Height Relative to Pad Base: Leading	Sprocket Opening: Inner	Sprocket Opening: Outer	Overall Grouser Height: Inner	Overall Grouser Height: Outer	Overall Grouser Height: Leading	Track Shoe Wt (lb)
S 1	1 10/32	1 11/32	1 13/32	3	3	2 9/32	2 7/32	2 11/32	16.18
2	1 11/32	1 12/32	1 13/32	3	3	2 8/32	2 7/32	2 9/32	15.70
3	1 10/32	1 11/32	1 13/32	3	3	2 9/32	2 9/32	2 9/32	16.11
4	1 10/32	1 10/32	1 13/32	3	3	2 9/32	2 9/32	2 11/32	16.35
5	1 10/32	1 11/32	1 13/32	3	3	2 9/32	2 9/32	2 12/32	16.69
6	1 10/32	1 10/32	1 13/32	3	3	2 9/32	2 9/32	2 10/32	16.35
7	1 10/32	1 10/32	1 14/32	3	3	2 10/32	2 9/32	2 11/32	16.55
8	1 11/32	1 10/32	1 13/32	3	3	2 10/32	2 9/32	2 11/32	16.46
9	1 11/32	1 11/32	1 12/32	3	3	2 10/32	2 10/32	2 11/32	16.47
10	1 10/32	1 10/32	1 14/32	3	3	2 9/32	2 9/32	2 10/32	16.54
11	1 11/32	1 10/32	1 13/32	3	3	2 9/32	2 10/32	2 11/32	16.40
12	1 10/32	1 9/32	1 14/32	3	3	2 9/32	2 9/32	2 11/32	16.84
13	1 11/32	1 10/32	1 12/32	3	3	2 9/32	2 9/32	2 10/32	16.40
14	1 10/32	1 11/32	1 14/32	2 31/32	3	2 8/32	2 10/32	2 10/32	16.34
15	1 10/32	1 10/32	1 15/32	3 1/32	3 1/32	2 10/32	2 9/32	2 12/32	16.17
S16	1 11/32	1 9/32	1 12/32	3	3	2 9/32	2 10/32	2 10/32	16.41

TABLE 2. Track Shoe Measurements at Intermediate Inspection
(2047 Test Miles)

Shoe No.	Grouser Height Relative to Pad Base: Inner	Grouser Height Relative to Pad Base: Outer	Grouser Height Relative to Pad Base: Leading	Sprocket Opening: Inner	Sprocket Opening: Outer	Overall Grouser Height: Inner	Overall Grouser Height: Outer	Overall Grouser Height: Leading	Track Shoe Wt (lb)
C 1	1 1/32	1 4/32	1 5/32	3 1/32	3	1 30/32	2 2/32	2 6/32	15.17
2									
3	1 3/32	1 3/32	1 1/32	3	3 1/32	2 1/32	2 1/32	2	15.02
4									
5	1 3/32	1 2/32	1 5/32	3	3 1/32	2 2/32	2 2/32	2 3/32	14.97
6									
7A*	1 10/32	1 9/32	1 14/32	2 31/32	2 31/32	2 11/32	2 10/32	2 12/32	16.05
8A*	1 13/32	1 12/32	1 13/32	2 31/32	3	2 10/32	2 10/32	2 11/32	15.78
9	1 1/32	1 5/32	1 4/32	3	3 1/32	2 1/32	2 3/32	2 3/32	14.84
10									
11	1 1/32	1 4/32	1 5/32	3	3	2	2 3/32	2 4/32	14.99
12									
13	1 4/32	1 6/32	1 3/32	3	3 1/32	1 31/32	2 4/32	2 3/32	15.50
14									
15	1 1/32	1 6/32	1 1/32	3 1/32	3	2	2 3/32	2 3/32	14.60
C16									
I 1	1 2.32	1 2/32	1 6/32	3 1/32	3	1 31/32	1 31/32	2 3/32	14.88
2									
3	1 4/32	1 5/32	1 5/32	3 1/32	3	2 2/32	2 4/32	2 3/32	15.50
4									
5	1 4/32	1 4/32	1 6/32	3	3	2 2/32	2 4/32	2 3/32	15.40
6									
7	1 4/32	1 4/32	1 6/32	3	3	2 2/32	2 2/32	2 4/32	15.04
8									
9	1 2/32	1 6/32	1 6/32	3	3 1/32	2 1/32	2 4/32	2 4/32	15.42
10									
11	1 2/32	1 5/32	1 5/32	3	3 1/32	2 1/32	2 3/32	2 4/32	15.53
12									
13	1 3/32	1 6/32	1 6/32	3	3 1/32	2 1/32	2 4/32	2 4/32	15.32
14									
15	1 2/32	1 5/32	1 7/32	3	3	1 31/32	2 2/32	2 4/32	15.03
I16									
N 1	1 5/32	1 3/32	1 4/32	3 1/32	3	2 4/32	2 3/32	2 3/32	15.91
2									
3**	1 4/32	1 3/32	1 5/32	3 1/32	3 1/32	2 2/32	2 3/32	2 2/32	15.53
4***	1 2/32	1 3/32	1 5/32	3	3	2 2/32	2 2/32	2 3/32	15.42
5	1 4/32	1 4/32	1 4/32	3 1/32	3	2 2/32	2 3/32	2 2/32	15.70
6									
7	1 3/32	1 2/32	1 5/32	3 1/32	3	2 2/32	2 2/32	2 2/32	15.46
8									
9	1 2/32	1 5/32	1 5/32	3	3 1/32	2 1/32	2 4/32	2 3/32	15.30
10									
11	1 2/32	1 5/32	1 5/32	3	3 1/32	2	2 4/32	2 4/32	15.80
12									
13	1 2/32	1 4/32	1 5/32	3	3	2 1/32	2 4/32	2 5/32	15.95
14									
15	1 2/32	1 5/32	1 5/32	3	3 1/32	2 1/32	2 4/32	2 4/32	15.82
N16									
W 1	1 5/32	1 4/32	1 5/32	2 31/32	2 31/32	2 4/32	2 3/32	2 2/32	15.86
2									
3	1 4/32	1 4/32	1 6/32	2 31/32	2 31/32	2 4/32	2 4/32	2 4/32	16.07
4									
5	1 5/32	1 4/32	1 5/32	3	2 31/32	2 3/32	2 4/32	2 4/32	15.93
6									
7	1 3/32	1 2/32	1 6/32	3 1/32	3	2 2/32	2 1/32	2 3/32	15.50
8									
9	1 2/32	1 6/32	1 6/32	3	3	2 1/32	2 4/32	2 4/32	15.48
10									
11	1 3/32	1 6/32	1 6/32	3	3	2 1/32	2 5/32	2 4/32	15.52
12									
13	1 3/32	1 6/32	1 6/32	2 31/32	3	2 1/32	2 3/32	2 3/32	15.21
14									
15	1 2/32	1 6/32	1 6/32	3	3	2 1/32	2 4/32	2 5/32	15.67
W16									

*C7, C8 damaged and measured at 1538.6 test miles

**3A	1 13/32	1 12/32	1 14/32	3	3	2 10/32	2 10/32	2 11/32	15.85

Replacement for N3.

***4A	1 13/32	1 12/32	1 13/32	3	3	2 10/32	2 10/32	2 12/32	15.50

Replacement for N4.

TABLE 2. Track Shoe Measurements at Intermediate Inspection (Concluded)

Shoe No.	Grouser Height Relative to Pad Base			Sprocket Opening		Overall Grouser Height			Track Shoe Wt (lb)
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading	
S 1	1 5/32	1 6/32	1 8/32	3	3 1/32	2 5/32	2 6/32	2 4/32	15.94
2									
3	1 5/32	1 4/32	1 8/32	3	3	2 5/32	2 5/32	2 4/32	15.85
4									
5	1 5/32	1 6/32	1 7/32	3	3	2 4/32	2 5/32	2 5/32	16.39
6									
7	1 5/32	1 6/32	1 8/32	3	3	2 5/32	2 5/32	2 5/32	16.20
8									
9	1 5/32	1 7/32	1 6/32	3	3	2 3/32	2 5/32	2 6/32	16.20
10									
11	1 4/32	1 6/32	1 8/32	3	3	2 3/32	2 6/32	2 6/32	16.16
12									
13	1 5/32	1 7/32	1 6/32	3	3	2 3/32	2 5/32	2 4/32	16.14
14									
15	1 4/32	1 8/32	1 8/32	3 1/32	3 1/32	2 2/32	2 4/32	2 6/32	15.75
S16									

TABLE 3. Track Shoe Measurements at Final Inspection

Shoe No.	Grouser Height Relative to Pad Base			Sprocket Opening		Overall Grouser Height			Track Shoe Wt (lb)	Remarks*
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading		
C 1	29/32	31/32	1 1/32	3 1/32	3 1/32	1 28/32	1 30/32	2 2/32	14.78	FB2, FB3 3902
2	31/32	31/32	1 4/32	3 1/32	3 2/32	1 27/32	2 2/32	2 1/32	14.60	Bent outer wing 2794
3	1 1/32	1 1/32	1 2/32	3 1/32	3 4/32	1 31/32	2 1/32	2 2/32	14.90	FB2 2929
4	1 1/32	1	1 3/32	3 2/32	3 3/32	1 27/32	1 28/32	1 31/32	15.30	FB2 3578
5	1 2/32	1 1/32	1 5/32	3 1/32	3 2/32	2	1 31/32	2 2/32	14.83	FB3 2794
6	1 1/32	1 3/32	1 5/32	3	3 2/32	1 30/32	1 29/32	2 3/32	14.75	FB2 2794
7	BENT TRACK SHOES						NO MEASUREMENTS TAKEN			
8	BENT TRACK SHOES						NO MEASUREMENTS TAKEN			
9	28/32	1	1 2/32	3 2/32	3 1/32	1 29/32	1 30/32	2 2/32	14.56	4096 FB2
10	31/32	1 2/32	1 4/32	3 1/32	3 1/32	1 31/32	2 4/32	2 2/32	14.90	FB2 3055
11	31/32	31/32	1 2/32	3 1/32	3 2/32	1 28/32	1 30/32	2 1/32	14.63	4096
12	1	1 2/32	1 5/32	3	3	1 30/32	2	1 31/32	14.70	FB2 2794
13	31/32	1 2/32	1 3/32	3	3 1/32	1 27/32	1 30/32	1 31/32	15.28	FB2 3578
14	1 1/32	1 4/32	1 4/32	3 1/32	3	1 30/32	2 2/32	2 2/32	14.77	FB2 2794
15	31/32	1 2/32	1 3/32	3 2/32	3 1/32	1 26/32	1 29/32	2 1/32	14.42	FB2 3578
C16	1 2/32	1 4/32	1 4/32	3 1/32	3 1/32	1 31/32	2 2/32	2 2/32	14.57	FB2 2794
I 1	29/32	31/32	1 7/32	3 2/32	3 1/32	1 30/32	2	2 2/32	14.75	FB2 2929
2	31/32	1 2/32	1 5/32	3 2/32	3	1 30/32	2 1/32	2 3/32	15.23	FB2 3276
3	1 1/32	1 3/32	1 4/32	3 1/32	3	2	2 2/32	2 2/32	15.39	FB2 2929
4	28/32	1 1/32	1 4/32	3 2/32	3 1/32	1 29/32	1 29/32	2 1/32	15.00	FB2 & FB3 3578
5	31/32	1 1/32	1 3/32	3	3 1/32	1 28/32	1 28/32	1 30/32	14.97	4096
6	1 2/32	1 1/32	1 3/32	3	3	1 29/32	1 30/32	1 31/32	15.60	FB3 3578
7	1 1/32	1 1/32	1 5/32	3 1/32	3 2/32	2	2	2 3/32	14.81	FB2 3276
8	1 1/32	1 1/32	1 4/32	3 1/32	3	1 29/32	1 30/32	2 1/32	15.42	FB2 & FB3 3578
9	30/32	1 2/32	1 1/32	3 1/32	3 2/32	1 29/32	2	2 2/32	15.12	4096
10	30/32	1 1/32	1 2/32	3	3	1 27/32	1 31/32	2 2/32	14.78	4096
11	31/32	1 3/32	1 4/32	3 1/32	3 2/32	1 31/32	2 2/32	2 6/32	15.43	FB2 3055
12	1	1 4/32	1 3/32	3 2/32	3 2/32	1 31/32	2 2/32	2 3/32	14.88	FB2 3276
13	1	1 5/32	1 5/32	3	3 1/32	2	2 4/32	2 3/32	15.25	FB2 3055
14	1 1/32	1 3/32	1 3/32	3	3	1 27/32	1 31/32	2	14.66	FB2 3578
15	30/32	31/32	1 3/32	3 1/32	3 2/32	1 29/32	1 30/32	2 2/32	14.74	FB2 4096
I16	30/32	1 1/32	1 2/32	3	3 1/32	1 28/32	1 31/32	2 2/32	14.68	FB2 3902
N 1	1	1 3/32	1 4/32	3 1/32	3	2 2/32	2 2/32	2 2/32	15.79	FB2 2929
2	31/32	30/32	1 1/32	3 2/32	3 1/32	1 29/32	1 30/32	2 1/32	15.20	4096
3	1 4/32	1 3/32	1 5/32	3 1/32	3 1/32	2 2/32	2 3/32	2 2/32	15.53	FB2 2047
4	1 2/32	1 3/32	1 5/32	3	3	2 2/32	2 2/32	2 3/32	15.42	FB2 2047
5	31/32	31/32	1 1/32	3 2/32	3 1/32	1 30/32	1 30/32	2 2/32	15.39	FB2 3902
6	1	1	1 4/32	3 2/32	3 2/32	2	2	2 4/32	15.17	FB2 3276
7	30/32	30/32	1 1/32	3 2/32	3 2/32	1 29/32	1 29/32	2 2/32	15.20	FB3 3902
8	1	1 4/32	1	3 2/32	3 2/32	2 1/32	2 1/32	2 3/32	15.45	FB2 & FB3 3276
9	31/32	1 3/32	1 3/32	3 1/32	3 1/32	1 26/32	1 30/32	1 31/32	15.05	FB3 3578
10	31/32	1 3/32	1 3/32	3 1/32	3 1/32	1 30/32	2 2/32	2 2/32	15.63	FB3 3276
11	1	1 4/32	1 3/32	3	3 1/32	1 29/32	2 3/32	2 2/32	15.64	FB2 3463
12	29/32	1	1 2/32	3	3 1/32	1 28/32	1 31/32	2 2/32	14.80	FB2 4096
13	29/32	31/32	1 2/32	3	3 1/32	1 30/32	2	2 1/32	15.72	FB3 4096
14	1	1 4/32	1 3/32	3	3	1 27/32	1 31/32	2	15.20	FB3 3463
15	29/32	31/32	1 2/32	3	3 1/32	1 28/32	1 31/32	2 2/32	15.54	4096
N16	29/32	31/32	1	3 1/32	3 1/32	1 28/32	1 31/32	2 1/32	15.10	FB2 3902
W 1	1 2/32	1	1 3/32	3	2 31/32	2	1 29/32	2	15.63	FB3 3578
2	30/32	30/32	1 3/32	3 1/32	3 1/32	2	1 30/32	2 3/32	15.12	4096
3	1 2/32	1 4/32	1 1/32	2 31/32	2 30/32	2 2/32	2 2/32	2 4/32	15.96	FB3 2608
4	30/32	1	1 1/32	3 1/32	3 1/32	1 30/32	1 30/32	2 2/32	15.22	FB2 4096
5	1 1/32	1 2/32	1 3/32	3 1/32	3 1/32	2 1/32	2 2/32	2 4/32	15.80	FB3 3276
6	1	1 3/32	1 3/32	2 31/32	2 31/32	2	2 2/32	2 2/32	15.14	FB2 2929
7	1 1/32	1 1/32	1 2/32	3 1/32	3	2 2/32	2 2/32	1 30/32	15.42	FB3 2929
8	31/32	31/32	1 3/32	3 2/32	3 1/32	1 30/32	1 31/32	2 1/32	14.91	FB2 3902
9	29/32	1 2/32	1 3/32	3	3 1/32	1 29/32	2 1/32	2 3/32	15.14	FB2 FB3 3902
10	31/32	1 1/32	1 3/32	3	3	1 30/32	2 1/32	2 2/32	15.44	FB3 3578
11	1	1 4/32	1 5/32	3 1/32	3	2	2 3/32	2 4/32	15.37	FB2 3276
12	28/32	1 3/32	1 4/32	3	3	1 30/32	2	2 3/32	14.89	4096
13	1 1/32	1 4/32	1 3/32	3 1/32	3 1/32	1 31/32	2 2/32	2 3/32	15.00	FB2 3276
14	31/32	1 3/32	1 4/32	2 31/32	3	2 1/32	2 4/32	2 4/32	15.63	FB2 3055
15	29/32	1 2/32	1 2/32	3	3 1/32	1 29/32	2 1/32	2 3/32	15.36	FB3 3902
W16	25/32	1 1/32	1 3/32	3 1/32	3 1/32	1 28/32	2 1/32	2 2/32	15.04	FB2 3902

*Cause of failure and accumulated test miles at time of failure; FB2 or FB3 denotes failure of the bushings on the leading edge of trailing edge of the shoe, respectively.

TABLE 3. Track Shoe Measurements at Final Inspection (Concluded)

Shoe No.	Grouser Height Relative to Pad Base			Sprocket Opening		Overall Grouser Height			Track Shoe Wt (lb)	Remarks*
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading		
S 1	1	1 2/32	1 5/32	3 1/32	3 1/32	2	2 4/32	2 4/32	15.68	FB2 4096
2	1 2/32	1 4/32	1 6/32	3 1/32	3 1/32	2 1/32	2 3/32	2 6/32	15.25	4096
3	1 1/32	1	1 6/32	3 1/32	3 1/32	2	2	2 6/32	15.57	FB2 4096
4	1 6/32	1 6/32	1 6/32	3	3	2 3/32	2 1/32	2 7/32	15.98	FB2 2794
5	1 2/32	1 3/32	1 5/32	3 1/32	3	2 2/32	2 3/32	2 6/32	16.20	4096
6	1 1/32	1 4/32	1 5/32	3	3 1/32	2 1/32	2 4/32	2 5/32	15.99	4096
7	1 2/32	1 3/32	1 6/32	3 1/32	3 1/32	2 2/32	2 4/32	2 5/32	16.00	FB2 3902
8	1 3/32	1 3/32	1 5/32	3 1/32	3 1/32	2 3/32	2 3/32	2 5/32	16.02	4096
9	1 6/32	1 8/32	1 2/32	3 1/32	3 1/32	2 5/32	2 5/32	2 3/32	16.01	FB3 2608
10	1 1/32	1 4/32	1 7/32	3	3	2 1/32	2 2/32	2 6/32	16.03	4096
11	1 2/32	1 4/32	1 5/32	3	3 1/32	2	2 4/32	2 4/32	15.94	4096
12	1 1/32	1 5/32	1 4/32	3	3 1/32	2	2 2/32	2 5/32	16.36	4096
13	1 1/32	1 4/32	1 4/32	3	3 1/32	2	2 4/32	2 4/32	15.94	4096
14	1 2/32	1 5/32	1 6/32	3	3	2 2/32	2 4/32	2 6/32	15.95	4096
15	1	1 3/32	1 7/32	3 2/32	3 2/32	2	2 4/32	2 6/32	15.76	FB2 4096
S 16	1 1/32	1 4/32	1 4/32	3 1/32	3 1/32	2	2 5/32	2 5/32	15.92	FB2 3902

*Cause of failure and accumulated test miles at time of failure; FB2 or FB3 denotes failure of the bushings on the leading edge of trailing edge of the shoe, respectively.

Item	Shortcoming	Suggested Corrective Action	Remarks
2.1.3			During test operation, rubber bushing failures were detected on T130 fuse-coated track shoes as follows:

Test Miles	Course[a]	Process	Code Number	Location of Failure: Leading Edge[b]	Location of Failure: Trailing Edge[c]
2794	LXC	Tape	C5		X
2794	LXC	Tape	C6,12,14,16	X	
2929	LXC	Spray	W6	X	
2929	LXC	Spray	W7		X
2929	LXC	Tape	C3	X	
2929	LXC	Sprinkle	N1	X	
2929	LXC	Slurry	I1, I13	X	
3055	LXC	Spray	W14	X	
3055	LXC	Tape	C10	X	
3055	LXC	Slurry	I11, I13	X	
3276	LXC	Spray	W5		X
3276	LXC	Spray	W11, W13	X	
3276	LXC	Sprinkle	N6	X	
3276	LXC	Sprinkle	N8	X	X
3276	LXC	Sprinkle	N10		X
3276	LXC	Slurry	I2, I7, I12	X	
3463	HXC	Sprinkle	N11	X	
3463	HXC	Sprinkle	N14		X

DEFICIENCIES AND SHORTCOMINGS
T130 FUSE-COATED TRACK SHOES

1. Deficiencies

None

2. Shortcomings

Item	Shortcoming	Suggested Corrective Action	Remarks
2.1	Failed bushings on track shoes	Improved bushing durability	
2.1.1			At 2047 test miles rubber bushing failures were detected on two experimental, T130 fuse-coated track shoes. The failures occurred at the inter-face of two track shoes which were fuse-coated by the sprinkle process. They were replaced by two track shoes which had been treated by the same method.
2.1.2			At 2608 test miles during operation on the tank gravel course, rubber bushing failures were detected on the trailing edge (three bushing side) of an experimental, T130, Code W3, fuse-coated track shoe. The failure occurred on a track shoe which was fuse-coated by the spray process. The unserv-iceable shoe was replaced with one that had been treated by the same method.

Item	Shortcoming	Suggested Corrective Action	Remarks					
							Location of Failure	
			Test Miles	Course[a]	Process	Code Number	Leading Edge[b]	Trailing Edge[c]
			3578	HXC	Spray	W1, W10		X
			3578	HXC	Tape	C4, C13, C15	X	
			3578	HXC	Sprinkle	N9		X
			3578	NXC	Slurry	I4, I8	X	X
			3578	HXC	Slurry	I6		X
			3578	HXC	Slurry	I14	X	
			3902	HXC	Spray	W8, W16	X	
			3902	HXC	Spray	W9	X	X
			3902	HXC	Spray	W15		X
			3902	HXC	Tape	C1	X	X
			3902	HXC	Sprinkle	N5, N16	X	
			3902	NXC	Sprinkle	N7		X
			3902	HXC	Slurry	I16	X	
			4096	Final Insp	Spray	W4	X	
					Tape	C9	X	
					Sprinkle	N12	X	
					Sprinkle	N13		X
					Slurry	I15	X	

[a]LXC - level cross-country; HXC - hilly cross-country
[b]Two bushing side
[c]Three bushing side

Item	Information	Suggested Corrective Action	Remarks
3.1	Two bent track shoes	None	At 1539 test miles, during operation on the hilly cross-country course two experimental T130 fuse-coated track shoes were bent when the vehicle grazed a large boulder as it traversed a narrow section of the course. The shoes were two of those which had been fuse coated by the tape process. They were replaced by two spare shoes fuse coated by the same company.
3.2	One bent track shoe	None	At 2794 test miles during operation on the level cross-country course an experimental T130 fuse-coated track shoe outer wing was bent. The shoe was one which had been fuse coated by the tape Process. It was replaced by a similar spare fuse-coated track shoe (code number C2).

TABLE 1. Track Shoe Wear at Intermediate Inspection

Shoe Number	Grouser Height Wear Relative to Pad Base (in.)			Sprocket Opening Wear (in.)		Overall Grouser Height Wear (in.)			Test Miles Completed
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading	
C 1	.344	.250	.281	.031	.031	.375	.281	.188	2047
2									
3	.281	.281	.375	.031	.063	.313	.281	.313	2047
4									
5	.281	.344	.281	.031	.063	.281	.250	.219	2047
6									
7	------------ BENT SHOES. NO MEASUREMENTS TAKEN ------------								
8									
9	.313	.250	.313	0	.031	.313	.250	.219	2047
10									
11	.313	.250	.281	.031	.031	.344	.250	.250	2047
12									
13	.281	.219	.344	.031	.063	.375	.219	.281	2047
14									
15	.344	.188	.375	.031	.031	.281	.219	.219	2047
C16									
Avg	.309	.253	.321	.028	.043	.325	.250	.240	2047
I 1	.344	.344	.250	.031	.031	.375	.375	.281	2047
2									
3	.250	.281	.281	.031	0	.250	.250	.250	2047
4									
5	.313	.313	.250	0	.031	.281	.219	.281	2047
6									
7	.281	.281	.250	0	.031	.250	.281	.250	2047
8									
9	.344	.219	.250	0	.031	.344	.219	.219	2047
10									
11	.344	.250	.281	.063	.063	.313	.250	.219	2047
12									
13	.406	.250	.281	0	.031	.375	.313	.219	2047
14									
15	.344	.219	.219	.031	.063	.344	.250	.188	2047
I16									
Avg	.328	.268	.259	.040	.034	.315	.268	.237	2047
N 1	.250	.281	.313	.031	0	.219	.250	.313	2047
2									
3	.281	.313	.281	.031	.031	.281	.219	.281	2047
4									
5	.281	.250	.313	.031	0	.313	.281	.313	2047
6									
N 7	.281	.344	.281	.031	0	.250	.344	.281	2047

TABLE 1. Track Shoe Wear at Intermediate Inspection (Concluded)

Shoe Number	Grouser Height Wear Relative to Pad Base (in.) Inner	Outer	Leading	Sprocket Opening Wear (in.) Inner	Outer	Overall Grouser Height Wear (in.) Inner	Outer	Leading	Test Miles Completed
N 8									
9	.313	.250	.281	.031	.031	.313	.219	.250	2047
10									
11	.313	.219	.281	0	.031	.344	.219	.188	2047
12									
13	.313	.250	.250	.031	.031	.344	.188	.250	2047
14									
15	.313	.250	.250	.031	.063	.313	.219	.250	2047
N16									
Avg	.293	.268	.281	.028	.025	.296	.243	.265	2047
W 1	.250	.344	.250	.063	.094	.250	.281	.313	2047
2									
3	.281	.188	.250	.031	.063	.219	.094	.313	2047
4									
5	.250	.250	.281	0	0	.219	.219	.281	2047
6									
7	.250	.281	.250	.031	.031	.281	.313	.344	2047
8									
9	.344	.219	.250	.031	.063	.344	.219	.313	2047
10									
11	.313	.219	.250	.031	.031	.344	.219	.281	2047
12									
13	.313	.219	.250	.094	.031	.344	.250	.344	2047
14									
15	.344	.219	.219	.094	.031	.375	.281	.281	2047
W16									
Avg	.293	.243	.250	.046	.043	.296	.234	.309	2047
S 1	.156	.156	.156	0	.031	.125	.031	.219	2047
2									
3	.156	.219	.156	0	0	.125	.125	.156	2047
4									
5	.125	.156	.188	0	0	.156	.125	.219	2047
6									
7	.156	.125	.188	0	0	.156	.125	.188	2047
8									
9	.188	.125	.188	0	0	.219	.156	.156	2047
10									
11	.219	.125	.156	0	0	.188	.125	.156	2047
12									
13	.188	.094	.188	0	0	.188	.125	.188	2047
14									
15	.188	.063	.219	0	0	.250	.156	.188	2047
S16									
Avg	.171	.134	.181	0	.003	.175	.121	.184	2047

NOTE: Only odd-numbered shoes were measured.

Incl 3 Page 2 of 5

TABLE 2. Track Shoe Wear at Final Inspection

Shoe Number	Grouser Height Relative to Pad Base (in.)			Sprocket Opening (in.)		Overall Grouser Height (in.)			Test Miles Completed
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading	
C 1	.469	.406	.406	.031	.063	.469	.406	.313	3902
2	.438	.438	.281	.063	.063	.469	.250	.344	2794
3	.344	.344	.344	.063	.156	.375	.281	.250	2929
4	.375	.344	.313	.125	.125	.500	.438	.375	3578
5	.313	.375	.281	.063	.094	.344	.344	.250	2794
6	.313	.281	.250	.063	.094	.406	.438	.219	2794
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
9	.469	.406	.375	.063	.031	.438	.406	.250	4096
10	.406	.281	.281	.063	.063	.344	.219	.281	3055
11	.375	.406	.375	.063	.094	.469	.406	.344	4096
12	.375	.313	.281	0	.031	.375	.344	.344	2794
13	.438	.344	.344	.031	.063	.500	.406	.406	3578
14	.344	.250	.281	.063	.031	.375	.281	.250	2794
15	.406	.313	.313	.063	.063	.469	.406	.281	3573
C16	.344	.250	.281	.063	.063	.344	.250	.250	2794
Avg	.387	.340	.315	.057	.073	.419	.348	.296	3255
I 1	.500	.438	.219	.063	.063	.406	.344	.313	2929
2	.438	.344	.281	.063	.063	.406	.344	.281	3276
3	.344	.344	.313	.031	0	.313	.313	.281	2929
4	.531	.375	.313	.063	.031	.438	.438	.313	3578
5	.469	.406	.344	0	.063	.469	.469	.438	4096
6	.344	.375	.344	0	.031	.438	.438	.375	3578
7	.375	.375	.281	.031	.094	.313	.344	.250	3276
8	.375	.375	.313	.031	0	.406	.438	.344	3578
9	.469	.344	.406	.031	.063	.469	.344	.281	4096
10	.500	.438	.375	.031	.031	.500	.406	.281	4096
11	.438	.313	.313	.094	.094	.375	.281	.156	3055
12	.375	.463	.344	.094	.031	.344	.250	.219	3276
13	.500	.281	.313	0	.031	.406	.219	.250	3055
14	.406	.313	.344	.031	0	.469	.406	.313	3578
15	.438	.438	.313	.063	.094	.438	.406	.313	4096
I16	.469	.406	.375	.063	.063	.563	.406	.313	3902
Avg	.435	.382	.375	.042	.046	.421	.365	.294	[illegible]
N 1	.406	.281	.313	.031	0	.281	.281	.344	2929
2	.406	.469	.406	.063	.031	.406	.438	.375	4096
3	.281	.313	.281	.031	.031	.281	.219	.281	2047
4	.313	.281	.281	.063	0	.219	.281	.281	2047
5	.438	.406	.406	.063	.031	.438	.438	.313	3902
6	.375	.375	.313	.063	.063	.313	.313	.250	3276
7	.438	.469	.406	.063	.063	.406	.500	.281	3902
N 8	.375	.250	.438	.063	.094	.344	.281	.281	3276

TABLE 2. Track Shoe Wear at Final Inspection (Concluded)

Shoe Number	Grouser Height Relative to Pad Base (in.) Inner	Outer	Leading	Sprocket Opening (in.) Inner	Outer	Overall Grouser Height (in.) Inner	Outer	Leading	Test Miles Completed
N 9	.406	.313	.344	.063	.031	.531	.406	.375	3578
10	.438	.313	.344	.031	.031	.438	.313	.344	3276
11	.375	.250	.344	0	.031	.438	.250	.250	3463
12	.469	.375	.344	.031	.031	.438	.375	.313	4096
13	.469	.406	.344	.031	.063	.438	.313	.375	4096
14	.406	.281	.281	.031	.031	.469	.375	.344	3463
15	.469	.438	.344	.031	.063	.469	.375	.313	4096
N16	.469	.406	.406	.031	.031	.438	.375	.281	3902
Avg	.408	.351	.349	.042	.039	.396	.345	.312	3465
W 1	.344	.469	.313	.094	.094	.375	.469	.375	3578
2	.469	.469	.344	.063	.094	.313	.406	.281	4096
3	.344	.188	.406	.031	.031	.281	.156	.313	2608
4	.438	.406	.406	.031	.031	.344	.438	.344	4096
5	.375	.313	.344	.031	.063	.281	.281	.281	3276
6	.375	.281	.344	.031	0	.313	.313	.375	2929
7	.313	.313	.375	.031	.031	.281	.281	.500	2929
8	.438	.406	.375	.125	.094	.375	.406	.344	3902
9	.500	.344	.344	.031	.094	.500	.313	.344	3902
10	.438	.375	.375	.063	.063	.469	.313	.344	3578
11	.406	.281	.281	.094	.031	.375	.281	.281	3276
12	.500	.313	.344	.031	.063	.406	.344	.313	4096
13	.375	.281	.344	.156	.063	.406	.281	.344	3276
14	.469	.281	.344	.063	.063	.313	.188	.250	3055
15	.500	.344	.344	.094	.063	.500	.375	.344	3902
W16	.625	.344	.375	.063	.063	.531	.344	.375	3902
Avg	.431	.337	.353	.064	.058	.378	.324	.337	3525
S 1	.313	.281	.250	.031	.031	.281	.094	.219	4096
2	.281	.250	.219	.031	.031	.219	.125	.094	4096
3	.281	.344	.219	.031	.031	.281	.281	.094	4096
4	.125	.125	.219	0	0	.188	.250	.125	2794
5	.250	.250	.250	.031	0	.219	.188	.188	4096
6	.281	.188	.250	0	.031	.250	.156	.156	4096
7	.250	.219	.250	.031	.031	.250	.156	.188	3902
8	.250	.219	.250	.031	.031	.219	.188	.188	4096
9	.156	.094	.313	.031	.031	.156	.156	.250	2608
10	.281	.188	.219	0	0	.250	.219	.125	4096
11	.281	.188	.250	0	.031	.281	.188	.219	4096
12	.281	.125	.313	0	.031	.281	.219	.188	4096
13	.313	.188	.250	0	.031	.281	.156	.188	4096
14	.313	.250	.188	0	0	.188	.188	.125	4096
15	.313	.219	.250	.031	.031	.313	.156	.188	4096
S16	.313	.156	.250	.031	.031	.281	.156	.156	3902
Avg	.267	.205	.248	.017	.023	.246	.179	.167	3897

TABLE 3. Wear Rate Analysis of Track Shoes $\left(\frac{\text{inches}}{\text{mile}} \times 10^{-4}\right)$

Shoe Code Letter	Grouser Height Relative to Pad Base			Sprocket Opening		Overall Grouser Height		
	Inner	Outer	Leading	Inner	Outer	Inner	Outer	Leading
At Intermediate Inspection, 2047 Test Miles								
C	1.5	1.2	1.6	.13	.21	1.6	1.2	1.2
I	1.6	1.3	1.3	.20	.17	1.5	1.3	1.2
N	1.4	1.3	1.4	.14	.12	1.5	1.2	1.3
W	1.4	1.2	1.2	.22	.21	1.5	1.1	1.5
S	0.8	0.7	0.9	0	0	0.9	0.6	0.9
At Final Inspection, 4096 Test Miles								
C	1.2	1.1	1.0	.18	.22	1.3	1.1	0.9
I	1.1	1.0	0.9	.11	.12	1.1	0.9	0.7
N	1.2	1.0	1.0	.12	.11	1.1	1.0	0.9
W	1.2	1.0	1.0	.18	.17	1.1	0.9	1.0
S	0.7	0.5	0.6	.05	.06	0.6	0.5	0.4

DISTRIBUTION LIST

NAME AND ADDRESS	NO. OF COPIES
Commander	
Yuma Proving Ground	
ATTN: STEYP-ADT	1
STEYP-MTM	6
TACOM Liaison Representative, Mr. Unger	2
Yuma, Arizona 85364	
Commander	
U. S. Army Test and Evaluation Command	
ATTN: AMSTE-BB	2
Aberdeen Proving Ground, Maryland 21005	
Commander	
U. S. Army Tank-Automotive Command	
ATTN: AMSTA-RKM, J. W. Schuster	1
Warren, Michigan 48091	
Commander	
Defense Documentation Center	
ATTN: Document Service Center	2
Cameron Station	
Alexandria, Virginia 22314	

Incl 4

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Yuma Proving Ground] Yuma, Arizona 85364	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP NA

3. REPORT TITLE
PRODUCT IMPROVEMENT TEST OF T130 FUSE-COATED TRACK SHES FOR M113A1 ARMORED PERSONNEL CARRIER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
First and Final Letter Report, 3 May through 26 October 1972

5. AUTHOR(S) (First name, middle initial, last name)
Richard Jordan, E2, Scientific and Engineering

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1973	22	2

8a. CONTRACT OR GRANT NO. b. PROJECT NO. TECOM No. 1-VG-017-130-013 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) YPG Report 0145 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None

10. DISTRIBUTION STATEMENT
~~Distribution limited to U.S. Government agencies only; test and evaluation; January 1973. Other requests for this document must be referred to Commander, U.S. Army Tank-Automotive Command, ATTN: AMSTA-RKM, Warren, Michigan 48091.~~ per E.R. M... 2/ RKM

11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY U.S. Army Tank-Automotive Command Warren, Michigan 48091.

13. ABSTRACT

A product improvement test of T-130 Fuse-Coated Track Shoes for M113A1 Armored Personnel Carrier was conducted from 3 May 1972 through 26 October 1972 at Yuma Proving Ground, Arizona. The purpose of the test was to evaluate the durability of the T-130 Fuse-Coated Track Shoes processed by four different methods as compared with production track shoes.

Endurance testing consisted of 4096 miles of operation.

It was concluded that there is negligible difference in wear between the four fuse-coating processes, that the standard T-130 track shoes showed approximately 45 percent less grouser wear than the fuse-coated track shoes, and that durability of the T-130 track shoe bushings is unsatisfactory.

It was recommended that more effort be expended on improving track shoe bushing life.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
T130 Fuse-Coated Track Shoes						
M113A1 Armored Personnel Carrier						

DISTRIBUTION LIST

ADDRESSEE	NO. OF COPIES
Commander US Army Tank-Automotive Command Warren, MI 48090 ATTN:	
Research, Development & Engineering Directorate, AMSTA-R	1
Chief Scientist, AMSTA-CL	1
Chief Engineer, AMSTA-CR	1
Systems Development Division, AMSTA-RE	1
Foreign Technology-International Affairs Off, AMSTA-RI	1
Technical Data Division, AMSTA-RS	1
Surface Mobility Division, AMSTA-RU	1
Propulsion Systems Division, AMSTA-RG	1
Technical Library Br, AMSTA-RPL	3
Armor, Material & Components Division, AMSTA-RK	1
Laboratory Support Function, AMSTA-RKAS	1
Materials Branch, AMSTA-RKM	10
Vehicle Branch, AMSTA-QED	1
US Army Weapons Command Liaison Office, AMSWE-LCV	1
US Army Combat Developments Command Liaison Office, CDCLN-A	2
Commander US Army Materiel Command ATTN: AMCRD-EA Washington, DC 20315	6
Commander US Army Natick Laboratories ATTN: Technical Libary Natick, MA 01762	1
Commander Picatinny Arsenal ATTN: SMUPA-RT-S Dover, NJ 07801	1
Commander Rock Island Arsenal ATTN: SARRI-LR Rock Island, Il 61201	1

ADDRESSEE	NO. OF COPIES
Commander Sharpe Army Depot ATTN: AMXSH-SO Lathrop, CA 95330	1
Commander Sierra Army Depot ATTN: AMXSI-DQ Harlong, CA 96113	1
Commander Tooele Army Depot ATTN: AMXTE-SEN Tooele, UT 84074	1
Commander Umatilla Army Depot ATTN: AMXUM-EMD Hermiston, OR 97838	1
Commander Sacramento Army Depot ATTN: AMXSA-MME Sacramento, CA 95813	1
Commander Red River Army Depot ATTN: AMXRR-MM Texarkana, TX 75501	1
Command US Army Armament Command ATTN: AMSAR-PPR-1W Rock Island, IL 61201	1
Commander US Army Missile Command ATTN: AMSMI-IIE Redstone Arsenal, AL 35809	1

ADDRESSEE	NO. OF COPIES
Commander US Army Aviation Systems Command ATTN: AMSAV-ERE St Louis, MO 63166	1
Director US Army Materials & Mechanics Research Center ATTN: AMXMR-M Watertown, MA 02172	1
Commander Letterkenny Army Depot ATTN: AMXLE-M	1
AMXLE-MM Chambersburg, PA 17201	1
Commandant US Marine Corps ATTN: Code AX Washington, DC 20380	1
Commander Air Force Materials Laboratory Wright-Patterson Air Force Base Dayton, OH 45433	1
Defense Materials Information Center Battelle Memorial Institute 505 King Avenue Columbus, OH 43201	1
Commander Harry Diamond Laboratory ATTN: AMXDO-PP Connecticut Ave & Van Ness Street Washington, DC 20438	1
Commander Seneca Army Depot ATTN: AMXSE-SE Romulus, NY 14541	1

ADDRESSEE	NO. OF COPIES
Commander Defense Documentation Center Cameron Station Alexandria, VA 22314	12
Office of Chief of Research & Development Department of the Army ATTN: CRDCM Washington, DC 20310	1
Quality Evaluation Laboratory Naval Ammunition Depot ATTN: Code 3031, Dr. Robert Klausmeier Crane, IN 47522	1
Commander Frankford Arsenal ATTN: SMUFA-L7000 Philadelphia, PA 19137	1
Commander Tobyhanna Army Depot ATTN: AMXTO-ME-B Tobyhanna, PA 18466	1
Commander Pueblo Army Depot ATTN: AMXPU-ME Pueblo, CO 81001	1
Director US Army Production Equipment Agency ATTN: AMXPE-MT Rock Island, IL 61201	10
Commander Materials Research Laboratory Ft Belvoir, VA 22060	1

ADDRESSEE	NO. OF COPIES
Commander Environmental Branch ATTN: STEWS-TE-AE White Sands Missile Range, NM 88002	1
Commander US Army Test & Evaluation Command ATTN: AMSTE-BB AMSTE-TA Aberdeen Proving Ground, MD 21005	1 1
Commander Anniston Army Depot ATTN: AMXAN-DM Anniston, AL 36201	1
Commander Atlanta Army Depot ATTN: AMXAT-MP Forest Park, GA 30050	1
Commander US Army Troop Support Command ATTN: AMSTS-PLC 4300 Goodfellow Blvd St Louis, MO 63120	1
Commander US Army Electronics Command ATTN: AMSEL-PP/P-IM 225 S 18th Street Philadelphia, PA 19103	1
Director Naval Research Laboratory Anacostia Station ATTN: Technical Information Center Washington, DC 20390	1
Commander Yuma Proving Ground ATTN: STEYP-RPT Yuma, AZ 85364	1

ADDRESSEE	NO. OF COPIES
Commander US Army Combat Developments Command Combat Arms Group ATTN: Materiel Division Ft Leavenworth, KS 66027	1
Commander US Army Combat Developments Command Combat Service Support Group ATTN: Materiel Division Ft Lee, VA 23801	1
Commander Watervliet Arsenal ATTN: SARWV-PPP-WP, Watervliet, NY 12189	1
Commander Army Research Office (Durham) Box CM, Duke Station Durham, NC 27706	1
Commander Blue Grass Army Depot ATTN: AMXLX-SE-1 Lexington, KY 40507	1
Commander Ft Wingate Depot Activity ATTN: AMXFW-M Gallup, NM 87301	1
Commander New Cumberland Army Depot ATTN: AMXNC-SM, New Cumberland, PA 17070	1

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Firestone Tire and Rubber Company Metallurgical Laboratory Akron, Ohio	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
Application Techniques and Methods for Applying Fused Carbides on Non-Lubricated Wear Surfaces for High Volume Production

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Phillip H. Brotzman
Egbert H. Drewes
Norman (NMI) Wulff

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
June 3, 1974		

8a. CONTRACT OR GRANT NO. DAAE07-71-C-0148	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 11850
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT
Approved for public release;
distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S. Army Tank-Automotive Command

13. ABSTRACT

Application techniques and methods for applying various commercially available types of fused carbides were studied. The non-lubricated wear surfaces of forged steel track shoes were used in this study.

900 track shoes were produced in total using four hard surface combinations. The track shoes were tested at Aberdeen Proving Ground and Yuma Proving Ground.

Examination of the four types of hard surfaced shoes after field testing revealed little difference in the rate of wear between the different types. All hard coatings were penetrated at approximately 1,000 miles. The cost of mass producing an induction hardened wear surface on a T130 track shoe is less than that of a mass produced fused carbide hard coat on the same shoe.

During the field testing, very few cracked shoes were observed in either the control or test group. However, Yuma Proving Ground indicated that standard induction hardened T130 track shoes showed 45% less grouser wear than hard surfaced T130 shoes. The standard T130 induction hardened shoe also appeared to have less wear at Aberdeen Proving Ground with the exception of the longer lasting, inboard corner of the front grouser. This inboard corner was on shoes with the tape method of application produced by Code C601.

'Continued'

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Abrasion						
Center Guide						
Chromium Carbides						
Fused Carbides						
Fuse Welding						
Grousers						
Hard Surfacing						
Induction Hardening						
Metal Slurry						
Metal Spray						
Metal Tape						
Non-Lubricated Wear						
Plasma Spray (Metal)						
Spray Welding						
Sprocket Windows						
Track Shoe, T130						
Tungsten Carbide						
Wear Resistance						

13. Abstract (Continued)

During the investigation production processes using furnace fusion were selected. A comparison between metal spray, slurry, and decal methods of application was made. The equipment and techniques of company Code I6A were readily adaptable for reproducible good quality fused carbide coatings on non-lubricated wear surfaces of track shoes. Company Code I6A has developed equipment, techniques, and personnel for hard surfacing agricultural implements on a production basis making their slurry process reliable and economical when compared to the less sophisticated metal spray and decal methods of application.